PB-217 723

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD). INFORMATION BULLETIN. NUMBERS 13-20, DECEMBER 1961 TO MAY 1964

Bureau of Waste Management
Rockville, Maryland

1969

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Groupe international d'étude pour les recherches sur les ordures ménagères

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NUMBERS 13–20

December 1961 to May 1964

Edited by John S. Wiley, Sanitary Engineer Director

Bulletins 13 and 14, translated by Warren L. Armstrong, Communicable Disease Center, U. S. Public Health Service.
Bulletins 15 and 16, translated by Ferguson, Brooks & Kelly, Consulting Engineers, Inc., Phoenix, Arizona, and Mr. Armstrong.
Bulletins 17 through 20, translated by Ferguson, Brooks & Kelly.

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Public Health Service
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ENVIRONMENTAL CONTROL ADMINISTRATION
Bureau of Solid Waste Management
ROCKVILLE, MARYLAND
1969

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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin Nos. 13-20
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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NO. 13

DECEMBER 1961

Warren L. Armstrong, translator
John S. Wiley, editor

Conference of der Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA) (Working Committee on Community Waste Disposal)
on
Processing and Utilizing Urban Refuse
July 20-21, 1961, Stuttgart, Germany

Introduction
by Dr. H. Straub, Secretary-General, AkA, Baden-Baden

The need to dispose of urban refuse in a sanitary and economical way has been comprehensively covered in earlier research papers and discussions by the AkA. The technical procedures, be they composting or incineration, have also been adequately described and explained. It now seems necessary, especially in composting, to learn about the decomposition of organic substances in order to establish optimal conditions for the process. Also, special characteristics of wastes to be incinerated must be recognized in order to follow the reactions occurring during combustion.

The AkA has established a series of committees concerned with these special problems. The committee on "Composting Plants" deals with operational problems of composting plants, the committee on "Plant Control and Storage Methods" considers questions concerning the testing of the compost produced, the committee on "Trade and Industrial Wastes" characterizes and describes the industrial wastes, and a committee still to be established on "Refuse Incineration" will study special problems concerning incineration. A technical committee, composed of authorities in the different fields, attempts to summarize and correlate the findings. The collective works are published in the AkA Year Book. In addition, combined sessions have been held with other committees of the Abwassertechnischen Vereinigung (ATV) (Sewage Works Association) and the Verbandes kommunaler Fuhrparks- und Stadtreinigungsbetriebe (VKF) (Association of Public Works and Sanitation).

The long-time objectives of AkA have been the study of all phases of community waste disposal and promotion of the development of technical procedures. Considerations are not limited to only incineration or to only composting. We recommend that the most favorable disposal method be selected after analysis of the refuse problem. The main objective for a city is to provide complete disposal of all community wastes. Only secondarily should cost reductions by more economical utilization of the refuse be attempted, such as by production of energy, salvage or compost. The ultimate objectives can only be attained by the collaboration of engineers, biologists and agriculturists. The membership of AkA is composed of representatives of these various categories and collaboration has thus far been excellent.

Although the papers this year, under the title "Processing and Utilizing Urban Refuse", deal exclusively with composting problems, it is because these problems are the most extensive. By many research grant projects it was possible to work out scientific bases for the technology, biology and soil science. We hope that the technical processes may be profitably built up on these bases. Their research work will be reported here by the investigators so that the results will be widely disseminated. Results will also be summarized in some publications. Problems on incineration, equally as important, will be dealt with in a session during 1962. We believe that these reports will bring us a step further in resolving the problems of refuse disposal by composting.

Physical, chemical and biological processes in composting are discussed by Dr. Farkasdi of Giessen, Dr. Pöpel of Stuttgart, and Dr. Banse of Bad Kreuznach; Dr. Sauerlandt of Braunschweig-Völkenrode will discuss problems on the use of compost in agriculture. Mr. Horstmann of Heidelberg will analyze the determination of the degree of compost decomposition as a criterion for its utilization. Finally, papers by Dr. Straub of Baden-Baden and Mr. Horstmann will give conclusions on the techniques of processing compost. Because, in the composting of sewage sludge and refuse, the problem of preliminary dewatering of sludge occurs, Dr. Schroeder of Niersverband Viersen reports on his extensive experiences in this field.

Part I: Biological Processes in Composting Urban Refuse

1. Contribution on the Microbiology of Composting by Dr. G. Farkasdi, Institut für landwirtschaftliche Mikrobiologie der Universität Giessen.

Composting is a process of decomposition, consisting of a number of concurrent or successively overlapping microbiological processes, the intensity of which is shown by the production of heat and gaseous products of metabolism. The rapidly changing environmental conditions first result in an explosion-like multiplication of numbers and species of microorganisms, followed by a rapid pasteurization which is necessary for the destruction of pathogenic species.

Some findings of research workers at Giessen University were reported at a previous session of AkA at Karlsruhe. Later a summary report of research conducted at Baden-Baden was published. This report will give a cross-section of the results of studies on the significance and role of mold fungi by Dr. (Mrs.) von Klopotek.

The works of Waksman (1), Fehér (2) and others showed that molds play an important role in the decomposition of organic matter. They are distributed everywhere in nature and their adaptability is astonishing; they are far less inhibited by unfavorable living conditions, such as low moisture content, low temperature, and high acidity of the substrate than are the bacteria. Waksman (3) found a stronger cellulose-decomposing activity with the same quantity of nitrogen by the fungi in comparison to actinomycetes and bacteria; lignin especially may be attacked and decomposed by the fungi.

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At Baden-Baden an unground raw refuse-sludge mixture is placed in windrows 3.5 m high and 8 m wide over a perforated pipe. Under the conditions at Baden-Baden, the fungi were present to a lesser extent than in other processes.

Rohde (4) in Berlin showed intensive proliferation of fungi throughout the pile in windrows 1.5 m high and 3 m wide which were provided with vertical air shafts 0.5 by 1 m in dimensions. Fungi appeared more in the procedure of Rohde, less in that at Baden-Baden. Rohde used low windrows with more extensive aeration, in Baden-Baden the high windrows had relatively reduced access to air.

The close association between the amount of oxygen available and the number of mold fungi was also confirmed by us in the observation that more fungi were found in the better-aerated layer near the surface than in the interior of the pile. In test series 8, in which the windrow height was varied, the lowest piles produced the most fungi and the highest piles the fewest. This holds true for both mesophilic and thermophilic species of fungi.

The relation of fungi to the moisture content of the piles was confirmed many times. More fungi were consistently present in dry piles or regions than in the wetter regions. Thus, in the first windrow in test 1 at measuring point 1 with a moisture content of 23.7% counts of 9 million mesophilic and 32 million thermophilic fungi were obtained; in windrow 3 of the same test with a moisture content of 38.5%, only 23,000 mesophilic and 40,000 thermophilic fungi were found.

The relation between temperature and fungi count was also plain. With increasing temperature, mesophiles multiplied rapidly at about 37°C and gradually subsided on further increase in temperature. Fungi could no longer be found at 67°C. Upon cooling, the mesophilic species again appeared and were more numerous; their initial number was only attained in dry piles, however. The thermophiles, on the contrary, did not multiply initially and their numbers decreased with increased temperature; they were no longer detectable after 3 days at a temperature of 64°C. Later, during the decrease in temperature, they multiplied intensively. This phenomenon can only be explained in that the heat is not a result, but a source, of their activity. In this material so rich in organic matter the mesophilic fungi played a greater role than the thermophilic fungi, but the mesophiles act only in company with the introduction of self-heating species because their activity decreases at higher temperatures.

Fungi develop to the greatest extent under optimum conditions in the most prominent zones of the piles, completely overgrowing the top 25 to 30 cm with white and pigmented mycelia. A layer similarly heavily overgrown with fungi was to be observed in most cases around the air pipe.

A notable observation was that the initial increase in fungi does not originate from uniform growth of the species present in the raw refuse but from a rapidly developing change in microbial flora. Fungi present in raw refuse were uniformly of few species, up to 70% consisting of Geotrichium. During heating, one species after another disappears until they are no longer detectable when the temperature exceeds 67°C. But heating continues to a maximum of between 70 and 80°C. One might therefore assume that the molds would be completely eliminated. However, this is not the case because a fungal flora again appears during cooling and it consists of only 3 species found at the beginning of the experiment. All other species appear for the first time. The assumption is therefore valid that it is a question of reinvasion. Even the fact that species are found which were present at the start is not proof that these survived the higher temperatures. Further study of this problem is required.

Frequently agronomists discuss the problem of whether it is sensible to compost urban refuse at all. Gardeners, horticulturists and winegrowers prefer compost; farmers, on the contrary, prefer as cheap a product as possible with a favorable long-term effect. Field trials at the Agricultural Institute have shown that the delayed benefits of raw refuse are superior to those of the compost.

It might therefore be conceded that raw urban refuse, which has relatively few pathogens, might be used directly on the soil after removal of objectionable materials and perhaps being ground to a degree. But two difficulties are encountered: agriculture cannot continually consume the (daily) yield of refuse and it has to be piled in heaps, i.e. be composted; and, if it is composted, the product must be hygienically safe in the same manner that is striven for in the composting of sludge mixtures. Great numbers of pathogenic microorganisms are present in sewage sludge, a fact which makes pathogen destruction absolutely necessary. There thus has to be drawn up a reasonable compromise between the desires of farmers and the requisites of hygiene.

To ascertain the time-temperatures required for the decontamination of urban refuse the individual composting processes must be tested by means of suitable experiments. The investigations should include animal and plant pathogens as well as those causing human diseases. To date the Baden-Baden process and the rasping system process at Heidelberg have been so tested. Dr. Knoll of the Hygiene-Institut, University of Giessen, conducted the experiments with intestinal bacteria of the typhoid-paratyphoid-enteritis group pathogenic to man.

In the Baden-Baden experiments, the pathogens were killed in a raw refuse-sludge mixture of initial 40-60% moisture content after about 14 days of action at a temperature of 55 to 60°C with at least one turning. The same observations were made with the Heidelberg rasping process. In control tests of the same materials stored at 5°C viable pathogens still remained after months.

Compost piles of relatively high moisture content or of deficient aeration often develop anaerobic decomposition zones. In these zones decomposition is slow and initial temperatures are low. Considering these zones, it could be assumed that a favorable environment exists for pathogenic organisms. In fact it can be demonstrated that pathogens remain alive for months in these zones. If the organisms get into a self-heating aerobic zone, as by turning, they perish within a short time. This fact underscores the great sanitary importance of turning.

The so-called "cold fermentation" has also been tested and it was observed that most of the pathogenic microorganisms inoculated survived temperatures below 40°C even after 5 months. Present knowledge therefore requires thermophilic decomposition to assure a hygienically safe compost.

Only a little has been reported to date on the survival of plant and animal pathogens in compost. Special danger to domestic animals useful in agriculture occurs only when sludge is mixed with the refuse. This holds particularly for cities with slaughterhouses, cattle markets, dairies, leather industries, etc. insofar as the wastewater therefrom is discharged into the sewerage system. Sludge from such sewage may contain animal pathogens in great numbers under certain circumstances. The causative agents of such diseases as hoof and mouth disease, hog cholera, chicken plague, hog erysipelas, brucellosis, and anthrax, among others, may be present. The use of refuse-sludge composts in agricultural operations involving animals can only be made when the composting methods guarantee the destruction of animal disease agents presumably present in the raw material. If this certainty is not given, veterinary authorities can include such a product in their epidemiological report in the case of an outbreak, and this could result in serious consequences to those producing the compost.

The inclusion of animal pathogens in the investigations of the Giessen research group was made by Dr. Strauch at the Veterinärhygienischen und Tierseuchen-Institut at the University.

First, the investigations included paratyphoid and hog erysipelas bacteria and the psittacosis virus; later, anthrax bacilli were included. The latter form spores which are very resistant to external influences and are capable of remaining alive and virulent for decades. Viable anthrax spores were found after 24 years at a soil depth of 1½ m at a site where an animal had been buried. It is thus considered unlikely that anthrax spores may be destroyed during composting.

The tests revealed that the paratyphoid, hog erysipelas and psittacosis agents were completely killed off under the practical composting conditions at Baden-Baden. For destruction of anthrax bacilli composting must occur over a period of at least 90 days at temperatures of over 65°C. A slow rise in temperature has proved favorable because the germination of spores occurs then under favorable conditions and the vegetative cells are more sensitive to the influences of the environment. It has been further shown that temperature is not the sole cause of pathogen destruction in composting. Certain antibiotic agents develop during composting which exert an antagonistic action on the pathogens being studied. These investigations will be continued including a study of other composting processes in order to determine the lowest time-temperature required for the elimination of anthrax bacilli.

Parasitological studies conducted by Dr. Bornkessel, under the direction of Prof. Wetzel, proceeded from the fact that the use of raw sludge for fertilizer in vegetable gardens and orchards if it is applied during the growing season implies direct danger to man. With the use of composts on the contrary in practice, only the eggs of the human tapeworm (Taenia saginata) that come from the sludge are of any importance when it is applied to pastures, because only then is there danger of closing the chain of infection - man to cattle to man. The investigations proved that worm eggs are completely eliminated by composting. Indeed, a prolonged action of temperatures over 40°C causes an increased metabolism and a rapid consumption of reserve substances causing the eggs to die.

The danger of importation of plant diseases of which the causative agents may be found in refuse (fruit and vegetable wastes) does not need to be particularly emphasized. Our group has investigated the clubroot (Plasmodiophora brassicae) and violet root rot disease (Rhizoctonia solani). The work unfortunately has had to be temporarily interrupted because of the retirement of Dr. Scheinpflug. But it can already be stated that, after the prolonged application of temperatures over 65°C, plant pathogens placed in the piles will have been destroyed.

It can be concluded from these studies that, with the exception of the seldom-occurring anthrax bacilli, neither excessively high temperatures nor month-long periods of action are required to eliminate the other pathogenic agents. There exists the possibility of coming closer to the wishes of the farmers without dispensing with hygienic requirements.

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(4) Rohde, G.--Lehrbuch der natürlichen Kompostierung. Berlin (1957).

2. Determination of Maturity of Compost by Mr. O. Horstmann, Municipal Works, Heidelberg.

If I, based on experience in operating compost plants, discuss a subject that preoccupies specialists, I am doing so because in our plant and in many inspections of others I recognize that the composting process cannot be conducted by simple rules and give reproducible results. Many mistakes can still be made and means for their avoidance are unknown. Thus, the compost is not always the same and, indeed, differences may be much greater than ordinarily assumed because each compost is subject always to an irregularly changing system of decomposition.

These differences arise from the composition and quality of the raw material, the process of decomposition, and the degree of ripeness (maturity) existing at the time the compost is applied.

In this conference, when discussion occurs as to whether raw refuse or ripe compost produces a better effect on soil and crops, it shows to what great extent we are still experimenting today. Lack of complete definition (analysis) of raw refuse and of the changes occurring between the moment of discard and that of utilization makes it difficult to answer the question of the degree of maturity of so-called finished compost.

The scientist can test samples from a few compost piles by means of plant experiments and he should attempt to obtain from the plant operator compost that has just become ripe. Probably selection of an older, rather than a younger (immature), compost is to be preferred for these experiments.

It is especially important to determine the degree of maturity when several composts from different plants or with different compositions are to be compared, or if it is desired to test methods of accelerating or regulating the decomposition by an entirely new process. Who assumes the responsibility of officially condemning or recognizing such new procedures? A practice may give such good results as to remove all scientific doubts regarding recognition. But it does not suffice today merely to differentiate between raw refuse and completely ripe compost. Many variants lie in between. Completely ripe compost may long ago have become over-ripe, that is a compost so far decomposed and mineralized that the name compost no longer applies. There is no measure that shows how far the decomposition of raw material has progressed and changed it to a stabilzed condition.

Degree of decomposition is of greater significance when refuse and sludge are composted, as is indeed the aim of most composting plants. In this case, the public health requirement of heating is necessary because of the large number of pathogenic microorganisms in the mixture. It is desired to compost only as long as absolutely necessary because the process requires certain area, labor and machinery. Composting should produce a hygienically satisfactory product above all else. If pathogens are found, it clearly shows that the treatment has been inadequate. Yet, if they are not found, proof is not necessarily shown that the processing has sufficed to destroy all the pathogens. It is entirely possible that certain portions were free of pathogens from the beginning. Other methods than bacteriological analyses therefore need to be developed to give information about the product.

Present knowledge indicates that the action of compost on crops occurs as follows:

Fresh, ground refuse (as from a rasping machine) is well tolerated by and increases yields of certain crops. There then occurs decomposition in which a depression in yield occurs (due to nitrogen fixation). The depression effect later vanishes and again changes to a positive effect as a degree of decomposition occurs in which the optimum crop benefit is achieved. At this point one might record the greatest success with relatively small applications. The compost ultimately decomposes further and greater amounts of this over-aged material are needed to continue improved yields. Superimposed on all this are differences in tolerability of the plants, variations in soil quality, and changes in application rates.

Recommended (application) amounts may be established once the degree of maturity (of a compost) may be determined that produces optimal conditions. Some experiments have already shown better results with considerably smaller amounts of refuse compost not considered completely matured than commonly used. If this proves correct, then price estimates, suitability for longer hauls, and marketing prospects could be re-evaluated.

The following might be said regarding the concept of degree of decomposition or of maturity: the process of decomposition is biological with a physical-chemical overlapping. One can determine neither a beginning nor an ending in practice. Decomposition proceeds violently under favorable conditions until the easily decomposable carbon is broken down. There then occurs a breakdown of difficultly-decomposable carbon and the formation of humus material, in which the appearance of actinomycetes is recognizable. There follows a ripening often spoken of as degree of ripeness instead of degree of decomposition. A certain degree of stabilization occurs with the decline in intensity of decomposition denoting a ripe compost. To avoid using the two expressions, degree of decomposition and degree of maturity, together, I recommend the term "degree of rotting" which includes both.

Development of a test for rotting is a truly scientific research problem which must be done in conjunction with the practice of composting to the point of maturity. The rotting test should not be confused with the test still to be developed for evaluation of a good compost. Compost testing will presumably involve long-term studies by a chemical or microbiological institute, but the test for degree of rotting must be usable immediately at any time during the composting.

Indeed, I would like to go a step further and offer the conjecture that knowledge of the degree of rotting used in test applications will also help permit recognizing the actual effect of compost and therefore its true value; that is, it will be learned whether the substances in compost and their availability produce the desired effects on crops, or whether other qualities, particularly those of a biological nature, make up the true value of a compost.

Methods of estimating the degree of rotting of a compost may be based on the following:

1. External characteristics (color, odor, structure).

2. Decomposition status (temperature, CO_2-content, O_2-content).

3. Physical analyses:

    a. Weight-volume
    b. Pore volume
    c. Particle size

4. Chemical analyses:

    a. Carbon-nitrogen ratio
    b. Nitrogen fractions (NH_3-N, NO_2-N, NO_3-N, and others).
    c. Cellulose content.
    d. Readily decomposable organic substances (oxidation with H_2O_2).
    e. Humus materials.

5. Biological analyses:

    a. Measurement of O_2-consumption or CO_2-production.
    b. Self-heating capacity.
    c. Thermokinetic method of Reinan.
    d. Number of thermophilic:mesophilic bacteria.
    e. Anaerobic test of Jann-Howard-Salle (shifting of pH value).
    f. Inhibitory action on Azotobacter or other test organisms.
    g. Counts of microorganisms.

6. Plant (crop) tests.

The above approximately corresponds to the classification by Dr. Keller, IRGR, Zurich, in Information Bulletin No. 10 which was extended by Dr. Farkasdi, Giessen.

The following applies to the individual methods:

1. External characteristics (color, odor, structure).

We agree with statements by Keller: "Determining degree of maturity with the aid of these observations may furnish some information if the observer is sufficiently experienced. There is great danger of erroneous interpretation, however, in the case of refuse and refuse-sludge mixtures; refuse compost, which has been mechanically ground and undergone only a brief period of decomposition in fermentation chambers, often looks bewilderingly like a mature compost although it is still far from ripe."

2. Decomposition status (temperature, CO_2-content, O_2-content). I consider that following the course of rotting in the compost piles is not always the simplest method for determining the degree of ripeness; requirements then include multiple turnings of the windrows and wetting when necessary. These prerequisites are not always fulfilled and erroneous conclusions may be reached, as in 1.

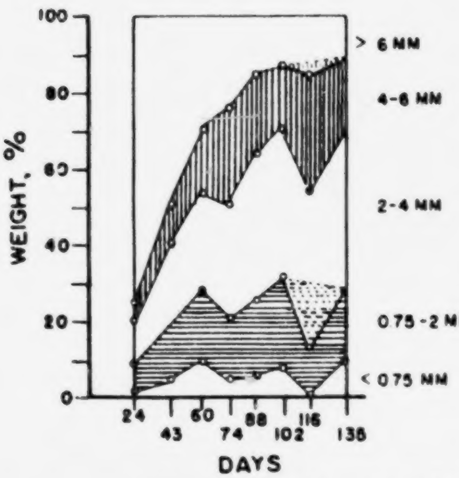
3. Physical analyses: a. weight-volume, b. pore volume. The common physical examinations for pore volume, moisture capacity and aeration capacity in comparison to weight-volume have not yet provided adequate information for estimating the degree of rotting. However, it is conceivable that these tests with other analyses, possibly including particle-size determinations, may become important.

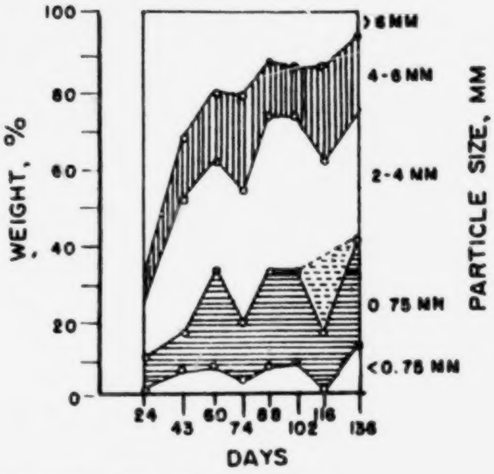
Our observation that a ripe compost absorbs more moisture than an unripe compost could certainly be shown in the laboratory and one might estimate the degree of rotting by the moisture-holding capacity.

As physical soil-improving effects of compost play an important role in its use, the inclusion of a physical criterion in the methods of analysis would be very welcome. Whether it would be used in estimating degree of rotting or in determining the value of compost (compost test), or for both, may soon be determined.

c. Particle size. An obvious method is testing the product by screening (sieve analysis). In 1954 Dr. Stöckli in Switzerland analyzed composts from both composting chambers and open windrows in this way. His results are shown in Table 1. They show that screenings through a 25-mm mesh sieve show definite differences according to the compost process used. The figures show that refuse decomposed in composting chambers shows greater decomposition than that composted in open windrows.

Whereas Stöckli used only one screen, four screens were used at the Heidelberg compost plant. Results of the windrow experiments with and without Edafil (an algal inoculating agent) are shown in Figures 1 and 2. Figure 1 shows that, of all particles, those originally having a diameter greater than 6 mm constituted about 75% of the total mass of refuse. Following decomposition, this amount had decreased to about 12%. The fractions 4-6mm and 2-4 mm in diameter showed a marked increase. Similar results are shown in the sieve analysis of refuse compost inoculated with Edafil (Fig. 2). The difference





SIEVE ANALYSES OF HEIDELBERG REFUSE COMPOST, 1960.

FIG. 1 WINDROW 1a, WITHOUT INOCULANT.

FIG. 2 WINDROW 2a, INOCULATED WITH "EDAFIL."

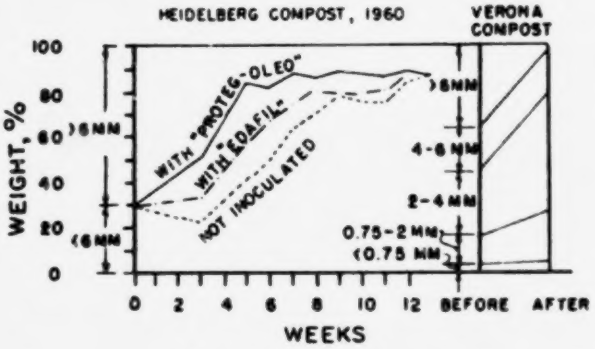


FIG.3 SEIVE ANALYSES

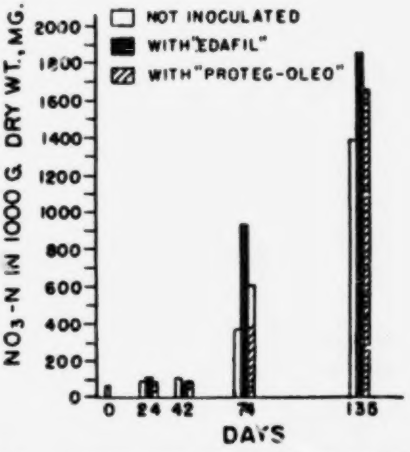


FIG. 4 NITRATE FORMATION DURING REFUSE COMPOSTING

Table 1
Increment of Degree of Rotting in Composting Chambers*
(Analysis Through 25-mm Mesh Sieve)

Initial Material	Composting Chambers		Open Composting	
	Screenings	Tailings	Screenings	Tailings
Hypericum (ground pine)	39.5%	60.5%	18.5%	81.5%
Mixed leaves	80.5%	19.5%	64.5%	35.5%
Lucerne	39.0%	61.0%	31.0%	69.0%
Urban street sweepings	64.5%	35.5%	50.0%	50.0%
Urban street sweepings	55.5%	44.5%	39.6%	60.4%

*From: Stöckli, A.-Probleme der Kehrichtkompostierung. Strasse und Verkehr, 40(5) 133-146, April 1954.

is that the total amount of coarser components decreased more in the inoculated windrow (1.b) than in the control windrow (1.a). Sieve analysis therefore provides a suitable method for estimating the rapidity or degree of decomposition of a given refuse.

The same analyses were performed with another inoculating agent for the acceleration of composting, Proteg Oleo. Figure 3 compares the 6 mm particle fractions (over and under) of inoculated composts with the control. The differences are obvious. I would also like to speculate that the development of friability is also demonstrated by the sieve analysis. Also shown is the progress of decomposition in the Multibacto-tower (Earp-Thomas digester) where we obtained well-mixed samples before and after passage through the tower of the plant in Verona [Ed. note: detention time is not stated but, judging from another plant under the same management, it is probably not more than 1 day].

Sieve analysis may be performed by dry or wet screening and further work on the method is needed. At the Heidelberg compost plant the material is air-dried for screening while that at the Blaubeuren works is screened in a fluid state.

4. Chemical analyses:

a. Carbon-nitrogen ratio: Various methods of determining C/N in refuse and refuse-sludge composts give different results which may deviate widely from one another. Therefore, the C/N value appears to be of only limited usefulness as a criterion for degree of ripeness or/and of decomposability of compost. Moreover the test will continue to be of concern to chemical institutes and is more suitable as a compost test rather than a rotting test.

b. Nitrogen fractions (NH_3-N, NO_2-N, NO_3-N, and others). It has been suggested that the nitrate content be used as an index of the actual degree of rotting of compost. The first such analysis, by the Institut für landwirtschaftliche Mikrobiologie, Giessen, showed this premise to be very dubious because it was shown that nitrate may be formed at even higher temperatures. It is quite likely that thermophilic organisms are of importance in this; these studies have not yet been completed.

That nitrate content indicates degree of ripeness is shown in Figure 4. In these experiments the inoculating agents Edafil and Proteg Olea were used. The various analyses, including pot experiments, showed that the additives speeded up the composting. The nitrate contents justify this conclusion.

Mattingly (G.E.G. Mattingly:- Changes in the distribution of nitrogen during the composting of straw. Nature (London) 169: 75-76, 1952) extended nitrogen tests to include ammonia and the nitrogen soluble in dilute acids or amides. It was found expedient to determine nitrate and ammonia together.

c. Cellulose content. Keller in Switzerland conducted analysis for the cellulose content on the basis of recognition that cellulose is the most widely distributed organic substance in nature. In Swiss refuse the proportion amounts to 30 to 60%. Keller found that 80 to 90% of the cellulose is decomposed during composting so that the cellulose content in various stages of decomposition might serve as a good criterion. German findings concerning this are unknown to me.

d. Readily decomposable organic matter (oxidation with H_2O_2). Professor Glathe writes concerning this: "A possibility of determination of degree of rotting consists in the oxidation of organic matter by hydrogen peroxide. Quantitative determination of the initial and final contents (oxidizable by hydrogen peroxide) gives information on the content of humic substances."

e. Humus materials. Because elucidation of the structure and constituents of humus compounds is extraordinarily difficult, it is presumed that such results would be less suitable for measuring degree of rotting than quality of a compost.

5. Biological analyses:

a. Measurement of O_2-consumption or CO_2-production. Carbon dioxide production and oxygen consumption can be indices of biological action. In our experiments (see IRGR Information Bulletin No. 11) CO_2-production was clearly demonstrable only in the first, very active, stage. Laboratory experiments using composters give a better picture of course, but they cannot presently be converted to practical operations.

b. Self-heating capacity. The self-heating capacity that the product has at the time of analysis offers an additional possibility for determination of degree of rotting of a compost. For this purpose small amounts are placed in Dewar flasks and the self-heating by them is measured. Figure 5 shows the results of two experiments conducted by the University of Giessen on compost from the Heidelberg plant in which the inoculating agent Edafil

SELF-HEATING OF COMPOST, EXPERIMENT 2, HEIDELBERG, 1960.

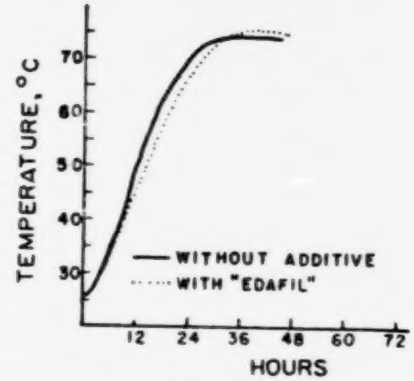


FIG. 5 COMPOSTING TIME: 24 DAYS

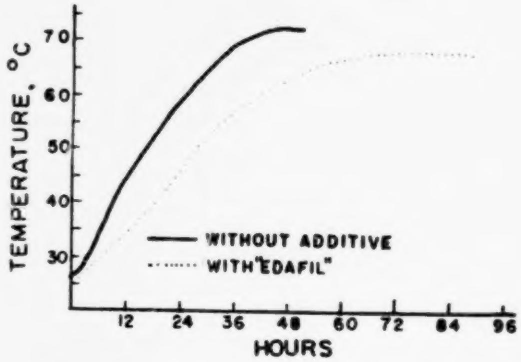


FIG. 6 COMPOSTING TIME: 42 DAYS

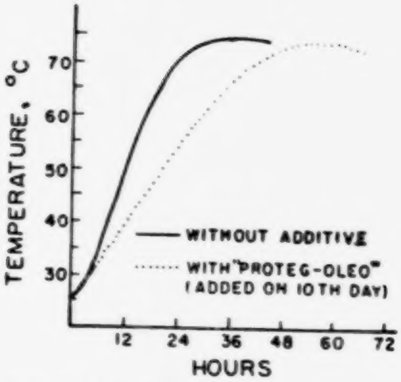


FIG. 7 COMPOSTING: TIME 24 DAYS

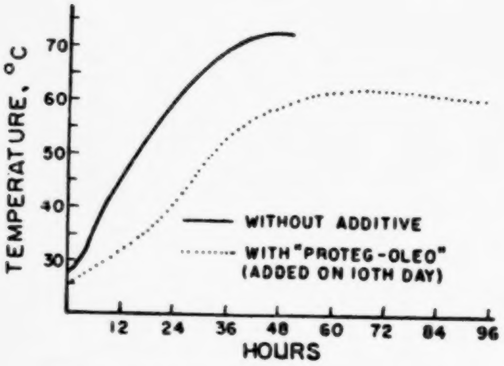


FIG. 8 COMPOSTING TIME: 42 DAYS

was used. After 24 days of composting (start of experiment) there was practically no difference between the two composts. However, after 48 days (Fig. 6) the compost treated with Edafil showed considerably less self-heating (than the control); specifically, less rapid rise in temperature and lower peak temperature. The same observations were made regarding the addition of Proteg Oleo as shown in Figures 7 and 8. After 24 days composting there was a less rapid increase in temperature but the same peak temperature occurred. After 48 days both rate of increase and peak temperature were considerably less in the compost with inoculant. This method thus permits obtaining information about differences occurring in composts within a few days. But this does not give an accurate objective measure of the condition, only a comparative measure. The research group at Giessen plans to use these results in additional experiments to develop an analytical method. Additional funds are expected from the Government Ministry of Atomic Energy (sic) for further experiments.

c. Thermokinetic method of Reinan. Prof. Reinan has developed a thermokinetic method of determining the biological activity of soils consisting of adding sugar to the soil. The soil (mixture) is then maintained at a constant temperature and the heating, caused by decomposition of the sugar by microorganisms, is measured by very sensitive thermometers. This method is therefore similar to that for the self-heating capacity. It differs in that only small amounts suffice and only slight temperature increases occur. Time required for determining thermokinetic analysis is less than that for self-heating capacity.

Prof. Reinan used Heidelberg compost to study the usefulness of this method for composts, using three different types of samples in triplicate (see Fig. 9). The results gave much information and confirmed those revealed by analysis of self-heating capacity, with certain variations. Aged winter compost which had a good appearance showed little activity remaining. This indicates that not only were the decomposable materials thoroughly broken down, but the microorganisms were already dead, there being too few to show significant activity after addition of sugar. More extensive heating occurred in summer refuse after composting for an 8-month period. Still greater temperature increases were shown with the same material taken from the center of the compost windrow where an excessive moisture content resulted in anaerobic decomposition (samples 7 and 8). Sample 9, from the innermost part of the anaerobic core of the windrow, showed considerable detrimental effect on the contrary.

The University of Giessen reports that it may try to combine the thermokinetic method with that for self-heating capacity, working out a new procedure from them.

d. Number of thermophilic:mesophilic bacteria. The relationship of thermophilic to mesophilic bacteria has been reported elsewhere, as in the Yearbook of the AkA, and the details need not be discussed here. It appears, however, that these determinations cannot be sufficiently simplified to permit wide use in practical operations.

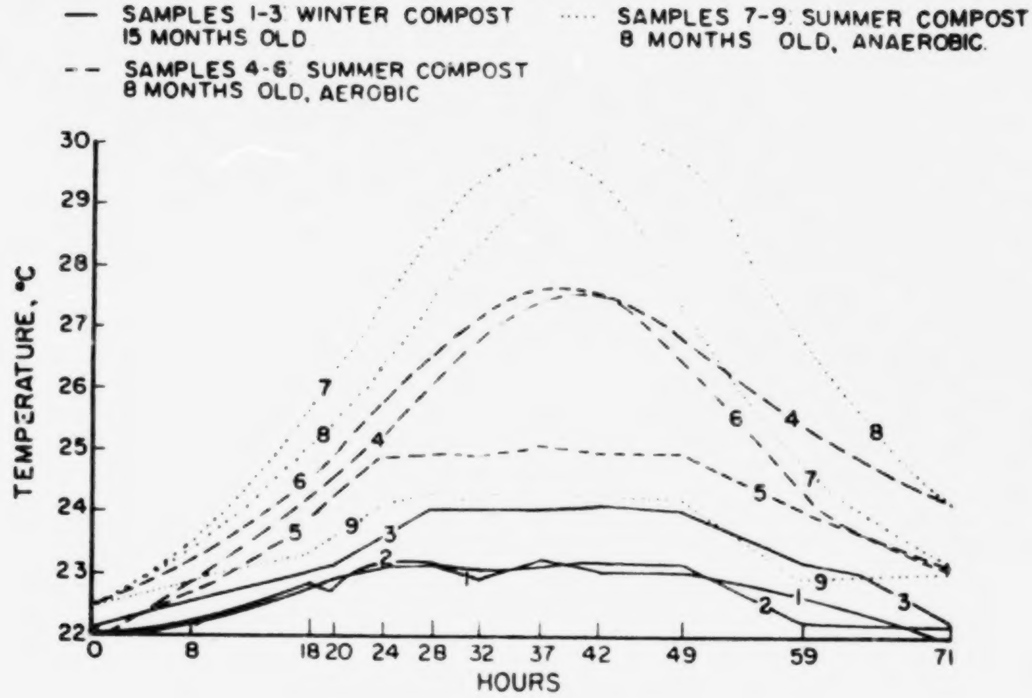


FIG. 9 THERMOKINETIC ACTIVITY OF HEIDELBERG COMPOST, MARCH 1959

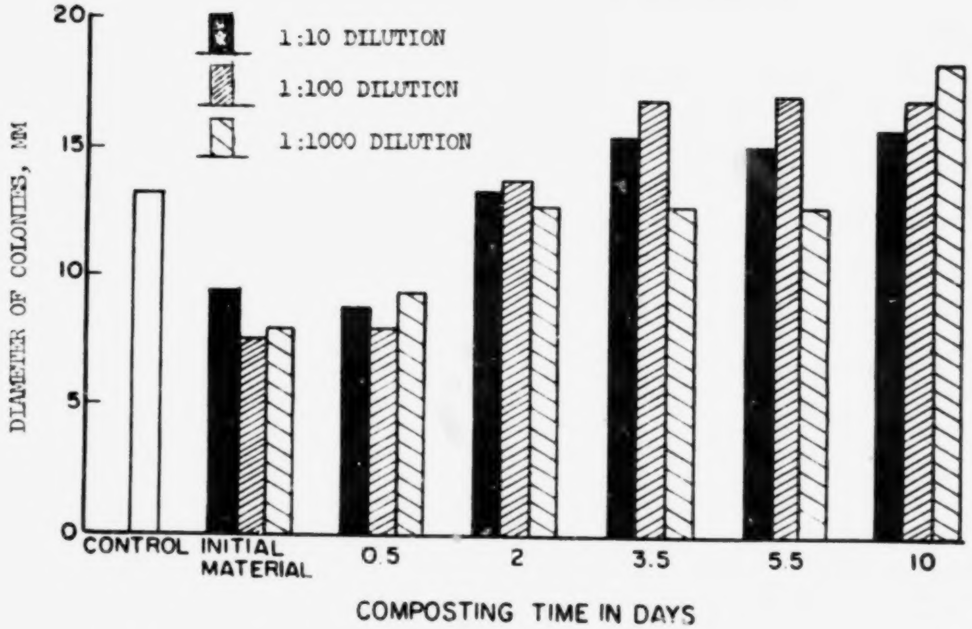


FIG. 10 EFFECT OF AQUEOUS EXTRACTS OF COMPOST ON GROWTH OF AZOTOBACTER IN NUTRIENT AGAR, 1960.

e. Anaerobic test of Jann-Howard-Salle (shifting of pH value). This method is described in Compost Science 1(3) 1960.

f. Inhibitory action on Azotobacter or other test organisms. Prof. Glathe reported that the degree of rotting of refuse compost can also be determined from its behavior on the bacteria *Azotobacter chroococcum*. Figure 10 shows results obtained with aqueous dilutions of various composts. The aqueous extracts were added to the media and the diameter of the colonies developing was measured. The graph shows that strong inhibitory action is caused by the extracts at first but this action is overcome after two days. After this time the growth is more prolific than that in the controls. It may be concluded that the detrimental effect can be surmounted in a very short time.

Table 2
Behavior of *Azotobacter chroococcum* in Compost

Azotobacter inoculating culture: about 16,500 organisms per gram, theoretically resulting in about 532 organisms per gram of compost. Cultures prepared on November 12 and December 26, 1959. Koch technique.

Date of Analysis	Number of Microorganisms per Gram				
	Stable Manure Compost, Darmstadt	Leaf Compost, Darmstadt	Raw Refuse, Baden-Baden	Raw Refuse + Sludge, Baden-Baden	Refuse-Sludge Compost, Baden-Baden
11-12-59	698	--	308	728	454
11-27-59	675	725	381	0	487
1-23-60	358	573	156	0	203
2-21-60	369	618	0	0	134
4- 8-60	66	2	0	0	20

	Raw Refuse, Bad Kreuznach	Refuse Compost, Bad Kreuznach
12-26-59	615	556
1-23-60	0	112
2-19-60	28	71
4- 8-60	0	0

Because compost itself, and not an aqueous extract, is applied (to the soil), it was necessary to study the activity of Azotobacter in the soil after addition of refuse composts. Table 2 shows that raw compost acts unfavorably on *Azotobacter chroococcum* in treated soils. However, Azotobacter is only one of the desirable bacteria in a fertile soil. Tests might be made with other microorganisms to see which are injured, at least temporarily, in the soil. Azotobacter may then possibly be considered the leading (test) organism and permit development of a suitable method to determine the condition of a compost in a relatively short time.

g. Counts of microorganisms. Included among these analyses is the microbiological tests of Dr. Rusch to whom we have sent several hundred compost samples from Heidelberg and other plants over a period of several years. While the results are of great interest and provide much information, they apply only at the time of sampling and do not sufficiently indicate the degree of rotting. These analyses therefore are more applicable to the testing of compost than to the rotting test. They provide additional information when the degree of rotting at a given sampling time is to be determined.

6. Plant (crop) tests. The germination test and plant trials must be considered as the most important tests. The compost test of course leads to the same end because the evaluation of compost depends on its action on the plants. But these trials are quite difficult and many factors influence the results. We have conducted many series of tests in conjunction with the Teaching and Research Institute for Horticulture in Heidelberg. Germination tests are relatively simple and they can provide some information. However, we have experienced plant tests that showed severe initial depressions and later outstripped all others. Thus, germination tests do not always suffice.

Because of the tediousness of such trials, there is need to determine first the degree of rotting of the samples by other means, otherwise the plant trials have only half as much value. In any event, plant trials do not provide a single test for estimating the degree of decomposition.

Summary

There exists a whole series of possible methods for determination of the degree of rotting. Each gives different information; some pertain to the initial decomposition and others rather to the more mature stages of compost. No one method indicates the entire range. Thus, several procedures have to be investigated and developed simultaneously. Then, perhaps, one may be selected as the one to be used from day to day in plant operation as being adequate with certain reservations and with occasional comparison by controls with other methods. This single test would, however, have to include a range of about 10 values such that the proper degree of decomposition would then lie at about 5 or 6 (similar to the pH scale or to the 5-day B.O.D. of sewage effluents).

Development of the method could be done using different composts or along with composting experiments in which various agents for acceleration of composting are used. The practice of composting would be greatly improved by development of such a test and we could proceed with greater reliability and more successful prospect in further work on refuse and refuse-sludge composting.

3. Effects of Moisture and Oxygen Contents on Refuse Composting by Prof-Doctor F. Pöpel, Technical College, Stuttgart.

To explore further the processes that occur in the composting of domestic refuse, investigations were made which are summarized in Tables 1 and 2. These studies involved 15 runs which in turn included from 1 to 9 individual experiments. The following specific problems were studied as possibly influencing the course of the decomposition process:

Run	Research Topics
1	Influence of wetting refuse on respiration and multiplication of microorganisms
2	Effects of different moisture contents
3	Comparative effects of water and sewage as refuse wetting agents
4-5	Effects of adding sewage sludge to refuse
6	Degree of rotting of previously composted refuse
7-8	Degree of rotting with and without self-heating of the refuse
9	Effect of variation in oxygen supply
10	Comparison of methods for measuring temperature in Dewar flasks for laboratory determinations
11	Effects of quantity and ventilation in Dewar flasks
12-13	Effect of varying the proportions of refuse and sludge in mixtures
14-15	Comparison of activated sludge, sewage, and water for wetting refuse

Table 1
Summary of Experiments on Biochemical Oxygen
Requirements of Decomposing Refuse

Run	Wetting Agent	Moisture Content, %	Average Temperature, °C	Composting Time, Hours
1	Water	38.8	26	102
2a	Water	34.0	26	220
2b		40.2	26	220
2c		46.1		
3	Wet sludge	37.7	26	257
4	Sludge from drying beds	50.2	26	304
5	Sludge from drying beds	47.1	26	357
6	Water	43.7	29	477
7a	Water	43.1	50.8	142
7b			26	
8	Water	44.1	44.9	215
9	Sludge from drying beds	40.0	N.D.	573

Dewar flasks were used in Run 7a; drums in all others.

Table 2
Summary of Experiments on Heat Production and Weight Losses of Decomposing Refuse in Dewar Flasks

Run	Wetting Agent	Moisture Content, %		Average Temperature, °C	Compost Time, Hours
		Initial	Final		
10	Water; varied temp	41.6			166
11 I-VI	Water; varied quantity and aeration	45.7	42.9	35.9-42.5	355
12 I-III	Sludge 4% from	40.0-48.2	37.0-39.0	39.8-45.1	381
IV-VI	drying 10%	40.8-52.1	37.6-52.9	42.6-46.9	381
VII-IX	beds 16%	39.6-53.0	36.1-52.9	41.6-45.2	381
13 I-III	Sludge 4% from	42.5-56.0	37.3-55.5	43.1-45.9	280
IV-VI	drying 10%	45.9-57.4	41.2-50.0	41.2-50.1	280
VII-IX	beds 16%	45.4-58.1	42.0-57.0	36.8-49.1	280
14 I-III	Activated sludge	31.2-61.2	24.4-58.7	29.8-40.0	336
IV-VI	Sewage	33.1-61.8	32.5-62.6	31.9-41.0	336
15 I-III	Activated sludge	33.7-45.9	23.5-46.4	44.3-51.5	327
IV-VI		31.8-44.9	31.5-45.9	42.6-45.2	327
VII	Water	39.6	33.5	42.5	327

Decomposition of organic matter in refuse was easily followed using an air circulation apparatus built at the Research and Development Institute, Stuttgart. Dried refuse was moistened with various agents such as distilled water, sewage, raw sludge, and activated sludge in these tests.

The following conclusions may be drawn from these studies:

1. Ground domestic refuse may be composted in laboratory units in the same way as in windrows.

2. Microorganisms in dry raw wastes multiply very rapidly after moistening and decompose organic matter with heat production.

3. Initial decomposition is performed predominantly by bacteria. Subsequently these are replaced largely by actinomycetes.

4. Rate of temperature increase, peak temperatures, and the respiration rate of microorganisms (O_2 consumed and CO_2 produced) are determined from the start by the moisture content of the refuse. Oxygen is better provided in moist than in wet sticky refuse, so the organisms use more oxygen. Temperatures increase more rapidly, reach higher peaks and persist longer in moist than in wet refuse.

5. Compost temperatures increased to 60-70°C three times as fast when held (in incubators) at a constant temperature of 26°C. The peak temperature of decomposition depends on an adequate supply of oxygen for the microorganisms. Temperatures drop if oxygen is cut off and increase immediately when it is again supplied.

6. By adjusting initial moisture and regulating the oxygen supply, the temperature of refuse decomposition can be controlled within certain limits. The course of decomposition varies with the moistening agent (water, sewage or sludges) with the same refuse and at the same initial moisture content. Activated sludge, raw sludge and sewage inhibit the temperature rise over that when water is used.

7. Losses in moisture and organic matter during decomposition depend on the magnitude of the temperature and are in direct proportion. At temperatures of 50°C (122°F), unnecessary solids and moisture losses are avoided. Yet the longer course of decomposition at this temperature produces just as safe (hygienically) an end product as shorter, higher-temperature decomposition.

8. Runs 1-9 indicate that a progressive estimation of the decomposition process is possible by determination of the respiratory quotient:

$$RQ = \frac{O_2 \text{ included in } CO_2}{O_2 \text{ consumption}}$$

Where RQ = 1, the total oxygen supply has been used for oxidation of carbon.

Where $RQ > 1$, more CO_2 is formed than is supplied to the compost from the outside. CO_2 is thus produced not only by oxidation of carbon but by means of anaerobic decomposition.

Where $RQ < 1$, only part of the oxygen available to the compost is being used to oxidize carbon, part of the oxygen supply is being used to oxidize other substances. Low RQ values therefore indicate aerobic decomposition processes.

A change in RQ during the course of composting is therefore an important factor in evaluating the process. An increasing RQ value signifies an anaerobic process, a decreasing RQ an aerobic process.

In these studies only a small portion of the total problem-complex could be clarified. It appears particularly important to investigate the following problems thoroughly:

1. In these studies only materials with a constant water-retention capacity were analyzed. Seasonal variations in refuse change the water-retention capacity and in turn influence the optimum moisture content. Further tests are needed with refuse of different origin and moisture-holding capacities; the latter may be increased by adding water-absorbing materials such as ashes.

2. Experience has shown that a very slight odor annoyance occurs in preliminary decomposition of refuse-sludge mixtures in vats or composting towers, probably due to an inadequate oxygen supply. This phenomenon may only be explained by additional studies of the effect of oxygen consumption on the course of decomposition. Present information indicates the need to analyze other gases formed during composting both qualitatively and quantitatively. Critical oxygen values can then be determined at which malodorous volatile products are released.

3. Present information is that the optimum C/N of raw refuse is 25-36. Adding activated or raw sludges tends to reduce C/N. Tests will show the effect of C/N on composting by wetting refuse to an optimal moisture content with various sludges.

4. Biological processes may be accelerated by introducing and mixing activated substances in a similar manner as in aerobic sewage treatment or in sludge digestion. Whether this procedure can also be used in composting refuse and sludge must still be studied. Final compost or decomposed material should be introduced into the composting cycle in various proportions. A buildup of acclimated microorganisms may be obtained by stepwise inoculation which will shorten the various phases of decomposition. Inoculation preparations on the market will have to be studied in this connection.

5. Much of the refuse consists of paper and cardboard. As this proportion will probably increase in the future, the amount of paper products that can be present in the refuse mixture without interfering unduly with the decomposition should be determined.

6. Unbalanced increases in carbon content of refuse must be counterbalanced by addition of substances containing nitrogen. Settled activated sludge, consisting mainly of bacterial protein, and raw sludge contain much nitrogen proportionately. Nitrogen in sludge must be converted to decomposable compounds to be made useful for the microorganisms causing decomposition. This may cause rapid oxygen use and depletion of oxygen and, in some cases, malodorous gases. These effects should therefore be checked by analyses.

7. The most important laboratory results should be checked on a pilot scale regarding their ability to be translated into practice.

Part II: The Effect of Refuse Compost on Soils and Plants

1. Evaluation of Various Refuse Composts in Field Trials by Prof.-Dr. W. Sauerlandt, Institut für Humuswirtschaft der Forschunganstalt für Landwirtschaft, Braunschweig-Völkenrode, Germany.

Development of refuse processing plants and testing of compost have been conducted for 7 or 8 years at the request of the AkA. While still not complete, the work requires a report of results and recommendations for the future. Some results of field trials with agricultural crop plants are therefore reported here. Agriculture could become a mass consumer of compost if its use is economical in money and labor. With low agricultural prices in the political economy, economic difficulties could develop in making possible extensive use of an agricultural fertilizer.

We have conducted the following experiments in recent years:

1955 to date: Refuse-sludge compost, Baden-Baden; the Straub process.

1956 to date: Refuse compost, Heidelberg; Dorr-Oliver process.

1958 to date: Refuse-sludge compost, Duisburg; Dano process.

1959 to date: Refuse compost, Kreuznach (in experiments without sludge); Dano process.

Not always the same plan was followed for the individual experiments. With the refuse-sludge compost from Baden-Baden, an experiment with reciprocal variation of refuse-sludge compost and mineral nitrogen was conducted. Studies of Heidelberg compost included ground (rasped) raw refuse and ground refuse compost, both tested with increasing applications of nitrogen. Incomplete results of experiments on refuse-sludge composts from Baden-Baden and from Heidelberg have been reported by C. Tietjen and K. von Gierke (1).

In studies of the Duisburg refuse-sludge compost, increasing additions of compost with or without mineral nitrogen were made. With Kreuznach compost, the degree of maturity was considered and both unripe material (immediately after leaving the biostabilizer) and windrowed material (after 9 months) were used. Simultaneously the nitrogen and phosphate were varied (N_0, N_1 and P_0, P_1).

Besides organic matter, considerable amounts of minerals are added to soils. Some of these, such as nitrate, phosphate, potash, magnesium, and especially lime, are able to act directly as fertilizers. Success in soil fertilization with refuse is correspondingly dependent on the degree of supplying plant nutrients.

Amounts applied and yields are summarized in table form. Results are only reported as to whether or not significant changes in the yields occurred and those significant at or exceeding the 95% probability level are so marked. Relative yield values are referred to the yield without refuse as equivalent to 100. From the number of tests, their duration, and determinations of principal and accessory yields of crops are obtained a collective value used to evaluate the variants in the field trials.

The sum of the individual values in the collective value, μ_K, amounts to:

Experiment: 66.....660 (6 years)
66a....324 (5 years)
66b....400 (3 years)
66c....324 (2 years)

Duisburg: Only during 1958 was a yield reported, using 75 tons per hectare of refuse-sludge compost in the series without mineral nitrogen, exceeding the confidence limits of GDl (p=99).

Baden-Baden: Primary yield increases occurred in 1955 and 1958; however, only in the second rotation was there an accessory (seconary) yield increase. In 1957 some values of the yield of straw (oats) showed statistically significant reductions in yield.

Heidelberg: A high proportion of statistically significant yield increases were achieved with the use of refuse compost and raw ground refuse.

Kreuznach: In the series without phosphates, refuse compost showed more definite increases in secondary plant yields.

(Ed note 1: In Figures 1-3, compost applications were made only in certain years as indicated by underlining; e.g., in 1955 and in 1958 for Figure 2. In Figures 4 and 5, no indications were given in the original drawings as to when compost was actually applied.)

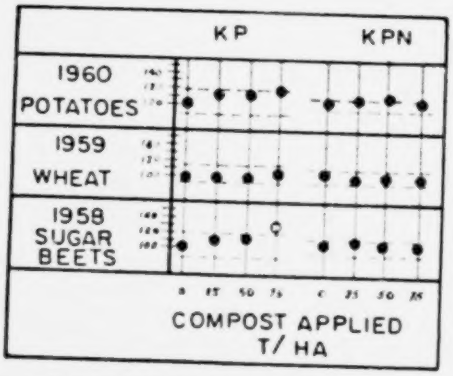
(Ed. note 2: In this report it will be noted that yields are expressed in three ways: total dry weight, primary yield, and secondary or accessory yield. The first probably refers to total dry weight of the entire test plants; the latter two presumably refer to the edible (food or feed) portion and the inedible portion of the test plants.)

Summary of Research Results

1. Heidelberg: Many factors enter into field trials to determine the benefits from compost application. In the Heidelberg trials (1), the soil was a slightly clayey, slightly humic, sandy soil of about neutral reaction and in good nutritional condition. There was generally a sufficient, well-distributed precipitation. Of 54 comparative results with ground refuse and refuse compost, 30% showed highly significant yield increases and an additional 33% showed slight but significant increases in yields. J. Kortleven (2) recommends the use of compost from mechanical units only because of the considerable loss of organic matter in windrows (prolonged composting).

2. Baden-Baden: The refuse-sludge additions likewise show clear-cut results. Increases in primary yields showed a satisfactory nitrogen uptake following both applications of compost and in both the series without nitrogen and the series with a half-dose of mineral nitrogen. When full nitrogen application

EFFECTS OF VARIOUS COMPOSTS, WITH AND WITHOUT ADDED NUTRIENTS, ON YIELDS IN FIELD TRIALS.



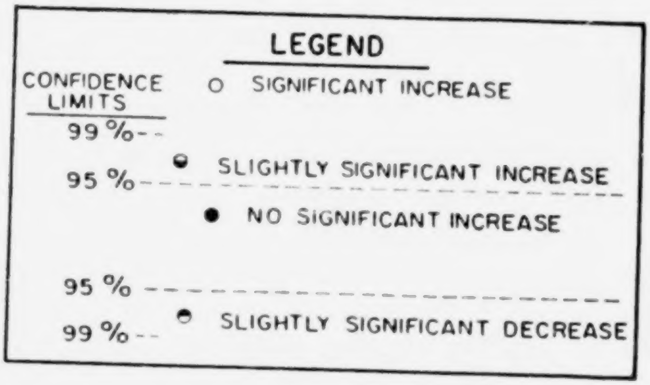
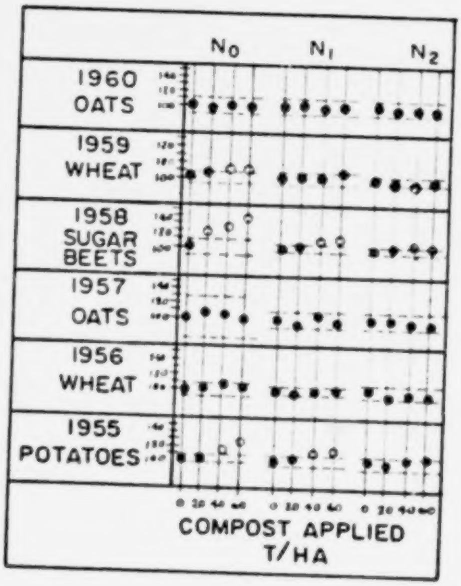
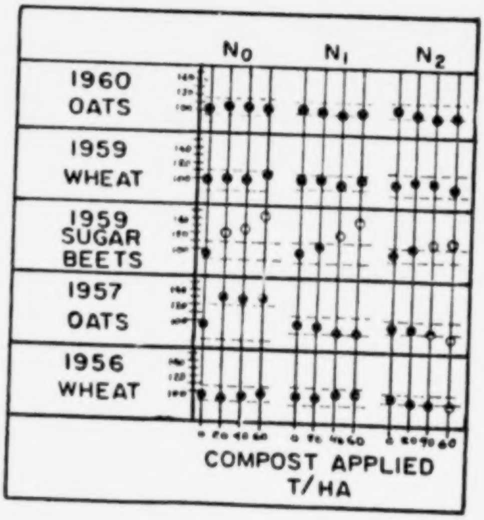

LEGEND
CONFIDENCE LIMITS
○ SIGNIFICANT INCREASE
99 %
95 %
SLIGHTLY SIGNIFICANT INCREASE
● NO SIGNIFICANT INCREASE
95 %
99 %
SLIGHTLY SIGNIFICANT DECREASE

FIG. 1 DUISBURG REFUSE-SLUDGE COMPOST

RELATIVE YIELD IN DRY WEIGHT





BADEN-BADEN REFUSE-SLUDGE COMPOST

FIG. 2 RELATIVE PRINCIPAL YIELD

FIG. 3 RELATIVE SECONDARY YIELD

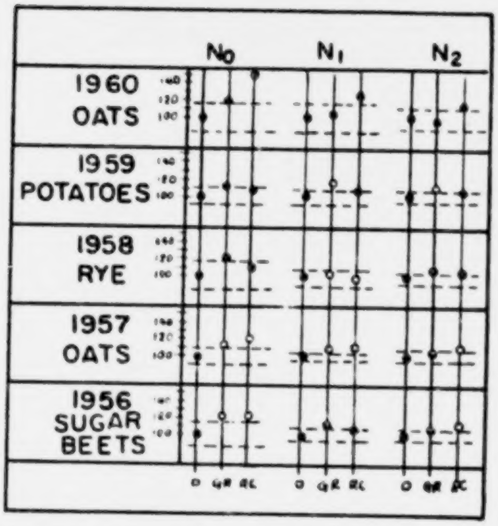


FIG. 4 HEIDELBURG GROUND REFUSE (GR) AND REFUSE COMPOST (RC), RELATIVE FOOD YIELD

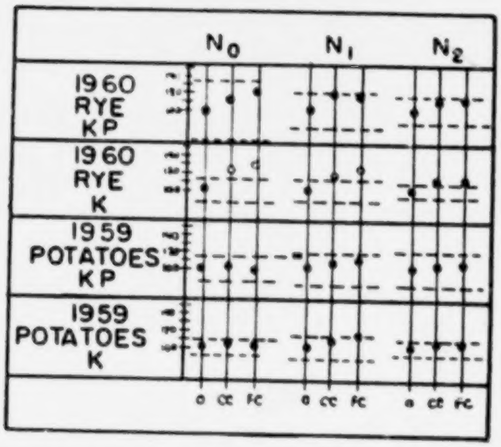


FIG. 5 KREUZNACH CURED COMPOST (CC) AND FRESH COMPOST (FC), RELATIVE TOTAL YIELD

was also made, the yield increases due to compost treatment were not shown to be statistically significant. In the first rotation period (1955-1957), no secondary yield increases were observed; in the second (1958-1960), significant secondary yield increases were noted in the series without nitrogen addition. This result hints that a lasting effect may, perhaps, be expected with more frequent (compost) applications.

3. Duisburg: Only in the series at the highest application rate (75 tons/ha) without added nitrogen was there a significant increase in yield. All other differences were not statistically significant. This series with refuse-sludge compost showed the least benefit.

4. Kreuznach: In the first year of use of refuse compost (1959) no effects were shown because of excessive dryness. Significant yield increases appeared in 1960 in the series without phosphate fertilization; the latter caused yield increases, particularly in plots without refuse additions, indicating an improved phosphate uptake by the plants. This series, running for only two years, is being continued.

5. Statistical evaluation of yield increases may be grouped on the basis of computation of the probability levels of statistical significance:

(I) Well verified - limit difference 0.1% ($p=99.9$)*
(I) Verified - limit difference 1.0% ($p=99$)
(II) Poorly verified - limit difference 5.0% ($p=95$)
(III) Not verified - limit difference greater than 5% ($p= <95$)

(*99.9% of the time the actual yield increases would be due to the effect of the compost and not due to chance.)

Summary Table
Yield Increases from Refuse and Compost Applications
Based on Statistical Verification Groupings

Run	Locality	Process	Time Refuse Collected	No. of Tests	Yield Increases Resulting by Probability Groups, % (I) 99.0-99.9	(II) 95	(III) <95
66a	Heidelberg	Rasped refuse	March		30%	33%	37%
66a	Heidelberg	Windrow compost	Sept.-Oct.	54	30%	33%	37%
66	Baden-Baden	Windrow compost	Autumn	99	18%	7%	75%
66c	Kreuznach	Dano compost	March or June	24	13%	12%	75%
66b	Duisburg	Dano compost	Autumn	18	6%	6%	88%

Discussion

Differences in results with the Baden-Baden refuse-sludge compost and the Heidelberg raw ground refuse require explanation. That from Baden-Baden is well-composted, the readily decomposable organic substances having been largely consumed during composting as has been thoroughly studied by H. Glathe and associates (3). There results only about 10% of utilizable organic matter remaining. Such compost has only a limited ability to supply plant nutrients later on. The ground raw refuse of Heidelberg has a high cellulose content and is rich in energy such that sheet composting occurred resulting in a high ability to furnish (nutrients) later on. Windrow and sheet composting differ in the quotient:

$$\frac{\text{Surface Area, sq.m.}}{\text{Organic Mass, tons}}$$

In windrows (piles) this quotient amounts to 5-10, perhaps lower; whereas in surface composting the value reaches about 500, depending on the amount applied. The lower quotient values result in heat production (up to 70°C or more) whereas the higher quotients result in liberation of heat to the air. Topsoil temperature is therefore only slightly increased.

This quotient of surface area over mass and the related degree of heat retention produces considerable differences biologically in the two composting methods. In windrows the mesophiles are overwhelmed by thermophilic organisms initially, then the mesophilic organisms return on cooling, and finally the compost may be invaded by small animals (worms). But in sheet composting (on the ground), small animals may be present from the start and, in addition to decomposition, new organic matter (in part humus substances) is formed which are very rich in nitrogen and possess high absorption capacity, as verified by Laatsch (11).

Composts rich in organic matter can act for a long time. Compost made from raw matter that is low in organic content may, when ripe, have a relatively high content of effective plant nutrients. It is then predominantly a carrier of nutrients but will not provide a long-lasting source of nutrients. An example is the refuse-sludge compost of Baden-Baden. J. Kortleven (2) indicates that those composts containing less than 10% utilizable organic matter provide no secondary (long-lasting) effects.

Hygienic considerations are important in the use of raw ground refuse. M. Knorr (4), based on decades of experience of using raw refuse on the Würzburg vineyards, sees no sanitary hazards in this method of application. K. H. Knoll (5) proved that, in a pile of composting refuse, antibiotic agents are formed such that *Salmonellae* are destroyed. L. Popp (6) demonstrated that *Salmonellae causing typhoid* and paratyphoid are rather rapidly killed off in the soil. In soil the peak microorganism count by the fluorescent antibody technique amounts to 2 to 8 billions/gram as E. Burrichter (7), A. Feldmann (8), and our own studies (9) have shown. It may be necessary to follow up the fate of pathogens in soil at the higher microorganism concentrations developing with raw refuse fertilization. High temperatures in compost piles, of course, have long been known to produce kills but the value of heating alone should not be overestimated and the benefits of surface composting, being more favorable with regard to conservation of energy, should not be neglected.

The following results were revealed in the agricultural testing experiments:

1. The greatest fertilizing effect was shown by ground raw refuse from Heidelberg, as well as composted refuse from the same source.

2. The Baden-Baden refuse-sludge compost showed a satisfactory primary effect but hardly any secondary effect (on yields).

3. After only three years of testing, the refuse-sludge compost of Duisburg, applied at 25, 50 and 75 tons/ha., have shown scarcely any influence on yields (primary or secondary).

4. Kreuznach refuse compost without sludge, tested for only two years, showed a greater yield increase than was expected.

5. As the Duisburg experiments show, the effect of the same compost on different genera of plants, i.e. fruit trees vs agricultural crop plants, can be very different, shown also by the investigations of Prof. Hilkenbäumer, Bonn. In addition the reduction of erosion, very important on slopes, may be less on level ground.

The value of refuse composts must be studied with regard to the many possibilities of use in agriculture, market gardening, horticulture, viniculture and forestry solely in connection with existing local conditions (climate, soil, plants). Greatest caution is advisable regarding generalizations.

While stable manure was highly esteemed 40 years ago for its nutrient content, the labor cost in agriculture caused farmers to seek ways of simplifying the work and yet maintain the soil in a good humus condition. This is possible through surface composting which is easily done by direct application of straw to the field soil as a mulch. This is the cheapest and probably the closest to natural composting. Refuse can also be used in this way.

Table 1
Run 66, Refuse Compost, Baden-Baden
Primary and Secondary Yields in Hundred weights per Hectare (cwt/ha), Fresh Weight

Compost, Tons/ha	N_0 Without Nitrogen						N_1 With 1/2 Nitrogen						N_2 With Full Nitrogen					
	1955 Pot.	1956 Wheat	1957 Oats	1958 Beets	1959 Wheat	1960 Oats	1955 Pot.	1956 Wheat	1957 Oats	1958 Beets	1959 Wheat	1960 Oats	1955 Pot.	1956 Wheat	1957 Oats	1958 Beets	1959 Wheat	1960 Oats
0	265	32.0	21.6	359	20.9	32.2	290	39.4	27.0	464	28.2	40.3	319	43.4	31.8	514	34.7	44.8
20	274	32.6	23.2	431	21.8	31.6	304	37.6	25.0	477	28.2	40.6	317	41.2	32.2	522	33.9	43.5
40	296	34.4	22.4	451	22.8	32.5	319	39.2	28.2	512	28.2	39.4	325	42.8	31.6	538	33.3	41.6
60	321	34.0	21.6	497	22.8	32.1	330	39.8	26.2	520	29.5	40.1	337	42.0	30.8	537	33.9	42.5
A GD 5%	14	2.4	5.9	37	1.1	3.2	17	1.8	2.8	24	1.8	3.9	20	3.3	3.2	23	1.0	4.1
1%	21	3.7	8.8	56	1.7	4.5	25	2.7	4.2	36	2.8	5.5	30	4.9	4.9	34	1.6	5.7
0.1%	31	5.4	12.9	81	2.5	6.4	37	3.9	6.1	52	4.0	7.8	46	7.2	7.1	50	2.3	8.0
0	---	53.8	20.4	176	28.3	36.5	---	69.0	33.8	295	37.8	44.8	---	84.4	37.4	473	44.8	50.6
20	---	52.2	27.2	219	28.7	37.3	---	69.2	33.6	313	38.7	44.5	---	80.2	37.2	516	46.5	48.3
40	---	53.2	27.0	229	28.5	37.3	---	71.0	31.0	365	37.2	42.4	---	80.8	34.2	546	45.2	46.5
60	---	55.4	27.2	260	30.4	36.9	---	71.4	30.6	419	38.7	43.8	---	78.2	33.0	557	42.6	47.7
B GD 5%	---	5.4	4.8	20	3.6	3.4	---	7.4	3.7	37	3.3	3.4	---	4.3	3.0	43	5.4	4.1
1%	---	8.1	7.3	30	5.4	4.8	---	11.1	5.6	56	5.0	4.8	---	6.4	4.5	64	8.1	5.7
0.1%	---	11.8	10.6	43	7.8	6.7	---	16.2	8.2	81	7.3	6.8	---	9.3	6.6	93	11.9	8.0

A = Primary crop yield

B = Secondary crop yield

GD 5% = Significant increase in yield at 95% confidence limits
GD 1% = Significant increase in yield at 99% confidence limits
GD 0.1= Significant increase in yield at 99.9% confidence limits

(Ed note: Compost was added only in the years 1955 and 1958.)

Table 2
Run 66a, Refuse Compost, Heidelberg
Yields in kg/ha, Fresh Weight

N	Organic Fertilizer	Sugar Beets 1956		Oats 1957		Rye 1958		Potatoes 1959		Oats 1960	
		Prim.	Second.	Prim.	Second.	Prim.	Second.	Prim.	Second.	Prim.	Second.
N_o	None	308	175	22.8	24.8	28.2	45.3	238	----	31.0	51.4
	Refuse compost	373	225	25.8	28.5	34.0	48.8	264	----	36.8	51.4
	Ground refuse	379	248	27.3	28.0	30.7	43.3	253	----	46.4	63.4
	GD 5%	39.7	20.4	1.8	3.2	4.7	10.0	22.9	----	5.0	9.3
	1%	64.2	33.0	3.0	5.2	7.5	16.1	37.1	----	8.2	15.4
	0.1%	106.3	54.7	4.9	8.7	12.5	26.7	61.3	----	15.3	28.8
N_1	None	395	260	29.0	29.0	35.7	52.5	242	----	42.3	63.0
	Refuse compost	446	328	31.8	30.5	37.5	57.0	278	----	44.9	65.7
	Ground refuse	422	331	32.5	32.5	35.2	48.3	652	----	53.1	67.8
	GD 5%	22.9	38.3	1.3	4.0	2.8	3.9	20.8	----	6.8	5.5
	1%	37.1	62.9	2.1	6.6	4.5	6.3	33.6	----	11.3	9.1
	0.1%	61.4	104.1	3.5	10.9	7.5	11.4	55.6	----	21.1	17.1
N_2	None	407	331	33.3	31.8	37.7	63.0	244	----	49.5	67.7
	Refuse compost	440	391	35.3	32.3	41.5	58.0	269	----	47.8	67.9
	Ground refuse	455	405	36.8	33.8	40.7	57.8	257	----	56.3	67.7
	GD 5%	24.1	47.7	1.8	3.4	2.4	14.1	11.5	----	5.3	8.8
	1%	39.1	77.2	3.0	5.5	3.9	22.9	18.7	----	8.8	14.6
	0.1%	64.7	128.0	4.9	9.2	6.5	53.1	30.9	----	16.4	27.3

(Ed. note: The years in which refuse or compost was added are not stated; presumably this was not done each year.)

Table 3
Run 66b, Refuse-Sludge Compost, Duisburg
Yields in cwt/ha, Dry Weight
(1960 - Potatoes, cwt/ha, Fresh Weight)

Nitrogen	Refuse-Sludge Compost, cwt/ha.	Sugar Beets 1958	Wheat 1959	Potatoes 1960
None	None	97.5	42.9	245.3
	250	102.2	41.3	269.4
	500	114.8	42.2	270.7
	750	120.4	42.9	280.1
	GD 5%	15.7	4.8	37.3
	1%	21.2	6.6	50.4
	0.1%	28.2	8.8	67.2
Added	None	187.2	63.7	325.6
	250	193.7	60.4	340.3
	500	190.8	62.8	345.6
	750	195.8	59.8	328.3
	GD 5%	17.5	5.7	21.1
	1%	23.7	7.7	28.5
	0.1%	31.5	10.3	38.0

(Ed. note: Compost additions were made only in the years 1958 and 1960.)

Table 4
Run 66c, Refuse Compost, Kreuznach, 1959-1960
Total Yields in cwt/ha

Year and Crop	Organic Fertilizer	Without P_2O_5			With P_2O_5		
		N_o	N_1	N_2	N_o	N_1	N_2
1959 Potatoes Fresh wt. of Tubers	Without refuse	154	139	145	155	141	141
	Refuse compost	160	147	151	159	150	145
	Ground refuse	160	156	151	154	154	147
	GD 5%	14.9	19.2	13.9	22.2	24.0	28.5
	1%	21.2	27.3	19.7	31.6	33.0	39.1
	0.1%	30.8	39.6	28.6	45.7	47.7	56.6
1960 Rye, Total Dry Wt., Grain & Straw	Without refuse	51.8	64.2	74.0	57.1	67.5	75.4
	Refuse compost	63.7	74.9	82.8	64.4	79.1	82.5
	Ground refuse	66.9	78.3	81.9	68.9	77.4	85.5
	GD 5%	7.2	7.8	6.4	20.2	13.3	11.3
	1%	10.4	11.4	9.3	29.4	19.4	16.5
	0.1%	15.7	17.0	14.0	44.1	23.1	24.7

(Ed. note: It was not stated whether compost was added in both years or only in 1959.)

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2. Influencing Physical Fertility of Soil by Application of Compost by Dr. H. J. Banse, Soil Improvement Society, Bad Kreuznach.

The soil is not only the habitat of plants but also the agency by which extremely important growth factors in both quantity and quality of yield are achieved. The mere presence of certain growth factors does not suffice; they must be completely utilized. The art of agricultural soil cultivation therefore consists of correlating growth requirements of crops and the natural environmental conditions by various measures in order to supply the best plant growth and yield.

If the soil is provided with the proper amounts and balance of nutrients and trace elements, this alone still does not guarantee high levels of yield. Among other factors, that of moisture content necessary to dissolve and transport the nutrients is of overwhelming significance on yields. Just as a deficiency of this important growth factor produces decreased yields, so also can an excess of water, as impounded water hinders respiration of roots or as soil on hillsides is eroded by the continued washing away of valuable constituents.

In the Kreuznach region, where the average precipitation is 400-450 mm, the area is exceptionally dry and our greatest difficulty is with the growth factor -- water. There are times when there is scarcely any precipitation for a quarter-year period. Then again there will be torrential rains such that the soil is unable to absorb it and deep furrows are cut in the slopes, washing away large amounts of friable soil (which is not very deep) and losing it for crop growing. This is particularly important in viniculture with exposed soil between the vines and steep slopes where the best wine grapes normally grow because of the more-intensive sunshine. It is here particularly important to use all of the precipitation and to avoid erosion damage as much as possible.

Earlier, organic fertilizers were given special significance in the maintenance and improvement of physical and biological soil characteristics and also for regulation of the water supply available to the soil. But it is here that a deficit now exists because of reduction in cattle raising and overemphasis on pure nutrient supplies in the care of vineyards. Without application of organic matter, regardless of form, it will be impossible to operate successful vineyards on healthy active soil over the years.

When the Kreuznach compost plant was opened, after realization of these concepts by well-known wine-growers, we immediately began planned experiments to test the suitability of refuse and refuse-sludge composts as a means of soil improvement and to make up the deficit in organic fertilizers.

The many geological formations, the forms of soil exploitation, and (cultivation) measures peculiar to the estates have resulted in greatly varying soils in the Kreuznach area with highly different mineralogical, physical, chemical and biological characteristics. We selected some fairly typical uniform soils in order to study the many variables encountered with the use of refuse and refuse-sludge composts. Our main studies were on the effect of composts on the physical qualities of the soil.

Refuse compost was first applied in 1959. The summer of 1960 was extraordinarily dry and the upper layers of soil (with compost) showed a considerably higher moisture content (than the control soil). Samples were taken in the bare, completely open, soil between the rows of (grape) vines. The water-retaining quality of the soil treated with compost was considerably greater. This was also true in subsequent years, indicating that a permanent improvement occurs following the application of composts.

In earlier investigations with Dr. Tietjen of Völkenrode, reported in IRGR Information Bulletin No. 8, 1-7, March 1960, we showed that the internal structure of compost piles had a favorable ratio of solids to water-filled and air-filled pore volume. If this ratio of solid matter to pore volume in compost windrows is important in the decomposition process, with a free exchange of pile air and atmospheric air, such a favorable ratio is also of value upon application of compost to soils. We were therefore interested in studying both ratios of water and air volume to the volume of solids. While the ratio of pore volume to soil substance is favorable in sandy soils, such infertile soils lack the ability to retain moisture and the pores are largely filled with air. On the contrary, loamy and clayey soils possess the ability to retain water, but often the air in the soil is then minimal. We may show that a healthy fertile soil contains soil aggregates caused by microorganisms and small animals (castings) producing a so-called friable soil. In such soils there are very fine capillary pores with larger connecting pores. The micropores take up moisture by capillary action and store it for growing plant roots. The macropores, on the other hand, are filled with air but become temporarily filled with water after heavy rains.

EFFECT OF COMPOST ON THE MOISTURE RETENTION OF SOME VINEYARD SOILS.

COMPOST USED, TONS PER HECTARE: —·—400, ---100, —·—50, ——NONE

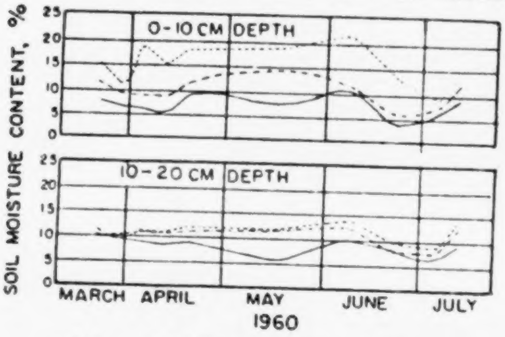

FIG. I ROXHEIM – SANDY LOAM SOIL

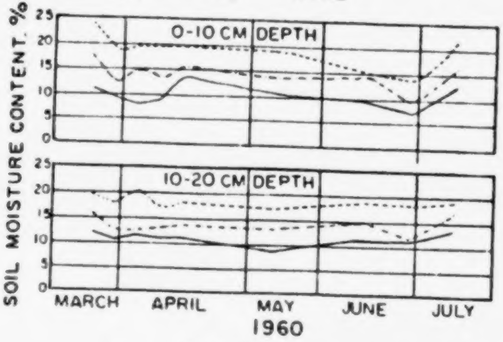

FIG 2 STEINBERG -- GRAVELLY TERRACE SOIL

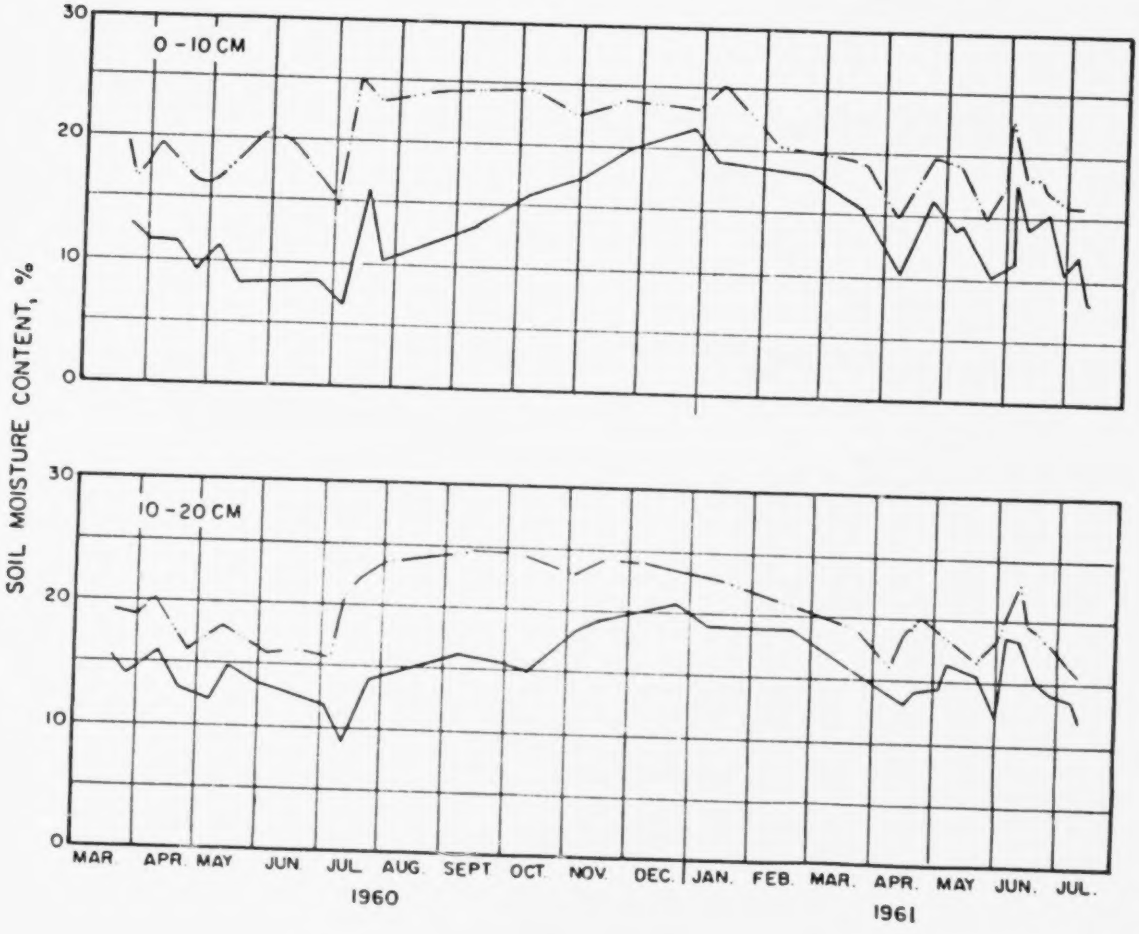

FIG. 3 ALTENBAMBERG -- GRAVELLY CLAY SOIL

If large amounts of refuse compost are mixed with a loam or clay soil, there results an improved soil structure which is more crumbly and loose (see figure 4). This soil was on a somewhat stony clay (loam) slope in which 55% of the solids consisted of stones, gravel and coarse sand and 45% of clay, fine sand and silt.

A whole series of questions arises with regard to the application of relatively large amounts of compost in relation to the best utilization of the soil. The physical properties of the soil may be modified to produce considerable change in soil structure. Results in vineyards have shown many times that marked effects are possible with the use of composts.

These experiments show that, where compost was applied to the soil, there was a marked reduction in volume of solids in contrast to pore volume. Air volumes were greatly increased in the soil containing 33 to 38% moisture by weight, a phenomenon of major significance in the respiration of roots and the avoidance of damage from chlorosis. In addition, the increase in pore volume led to an increase in moisture retention which, in the middle layer tested, was from 24.8% to 29.5% by weight. Similar results were also found during the previous autumn.

In the spring of 1961 two samples were taken 4 weeks apart which showed that the soil structure and the various components were not constant but varied greatly. All plots were cultivated on April 26 and it was found that working the soil was much easier in the composted plots. These effects were still clearly noticeable on May 8 when soil samples were taken because the soil was not in the meantime exposed to any packing action. In the next four weeks the vines required tending and also, early in June, over 100 mm of rain fell gradually. These two factors contributed to soil compaction. Samples of June 5, taken during an extended rain showed that there was no marked difference between plots watered in the laboratory and those in the fields receiving rain.

Comparison of the results shown in figure 5 reveal that composted plots mechanically loosened and then tramped down still have a greater pore volume than the control plots. With uniform rainfall, the composted soil retained a greater amount of moisture for a longer time than the control soil on May 8. At the second sampling, equal water volumes were found but the proportion of air was not nearly as extensively lowered as in the control plots.

Permeability tests showed that water ran through the soil treated with compost much faster than through untreated soil. That is, a fixed amount of water, poured through exactly 1000 cc of undisturbed soil taken with a boring cylinder, ran through the compost-treated soil more rapidly. In a period of an hour, under saturated conditions, the water ran through 10 cm deep soil samples of 1000 cc as follows:

Untreated soil	426 cc
Soil with 200 T/ha compost	750 cc
Soil with 400 T/ha compost	932 cc

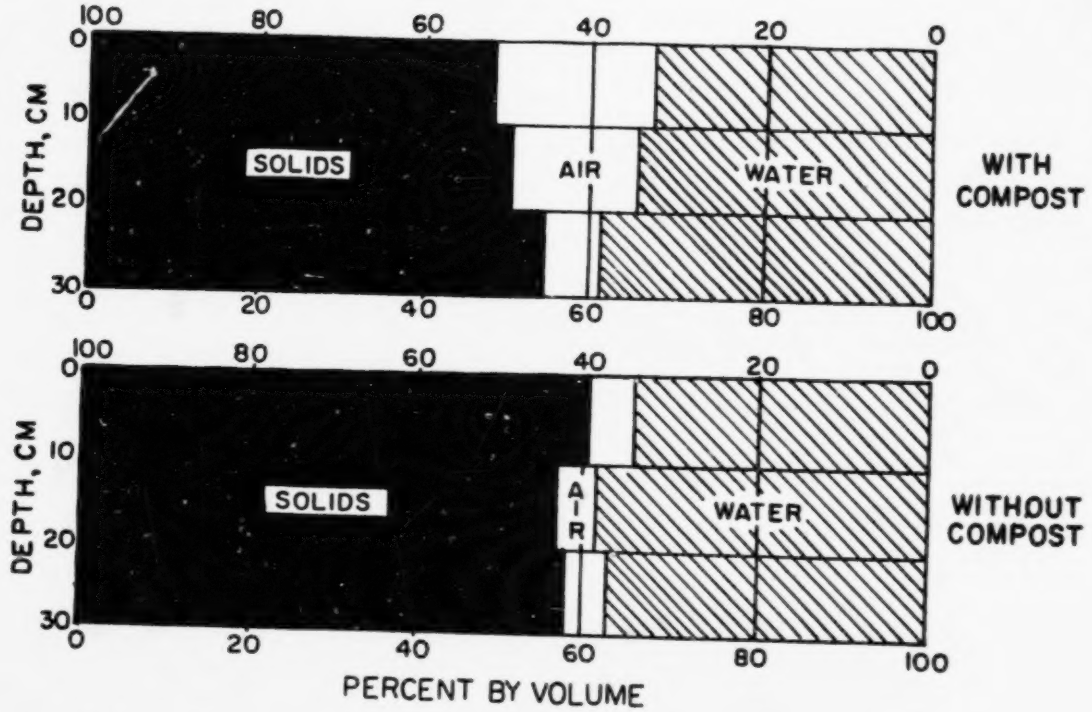

FIG. 4 STRUCTURE DIAGRAM OF ALTENBAMBERG SOIL, AUTUMN 1960

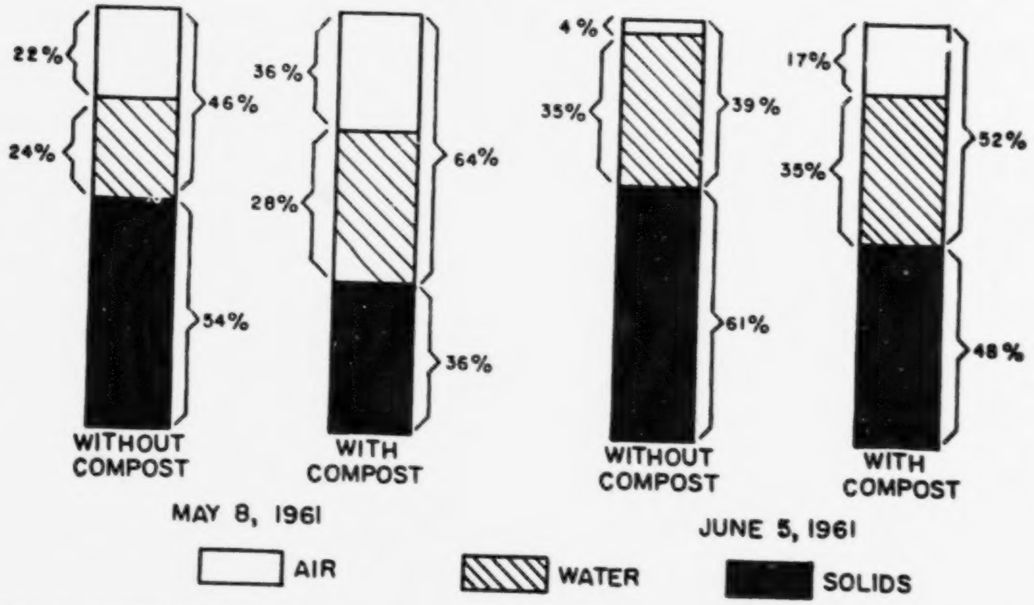

FIG. 5 STRUCTUAL CHANGES IN UPPER SOIL (0-10CM), ALTENBAMBERG

The compost also permitted retention of the finest soil particles which were partly washed away from the untreated soil samples. This phenomenon is of primary importance on the slopes of the vineyards and was also studied in the field. The field slope was 58% or an angle of inclination of 30°. By dividing the individual plots and setting up casks, we studied both runoff and soil erosion.

There were no rains causing soil erosion in 1959. The first heavy rain was in May 1960 when 39 mm fell in a little more than two hours. As the following table shows, considerable reductions in runoff and soil erosion occurred in the treated plots.

Compost, Tons/ha	Total Runoff per Plot, 1*	Eroded Soil Kg (dry wt.)		Fines, % <0.2 mm
		per Plot	per Hectare	
0	102.5	30.26	12,607.4	54.9
200	58.3	21.25	8,852.6	45.1
400	3.9	0.15	64.4	38.5

* 24 sq. m. slope area; 20 sq. m. horizontal area

Of most importance is the loss of fine particles shown in the last column. In the untreated soil 45% of the solids is in this fine fraction (less than 0.2 mm). There was considerably less washing away of fines in the compost-treated plots.

Further erosion occurred with time and resulted in losses of nutrients, clay and organic matter. While detailed descriptions may not be given here, it should be noted that large losses can result in poor soil conditions and that the use of compost reduces such losses by improving the soil structure. Although there is no absolute protection against erosion, even in the worst storms like that last autumn when over 70 mm of rain occurred in a very short time running over the road into the research plots, the composted plots suffered less damage than the untreated plots. The two pictures show some of the erosion damage in vineyards.

In summary, experiments in vineyards have shown that, with compost applications of 50, 100, 200 and 400 tons per hectare (selected this high on a research basis), considerable improvement of physical soil characteristics occurred, more so, of course, in the two higher application rates. In light soils the maintenance of soil moisture during drouth is of great importance and is accomplished by an increase in moisture-holding capacity. In heavy soils which cake during dry weather, the pore volume is increased through compost application thus improving the structure and the tilth of the soil. In times of heavy rainfall silting-up is prevented and good aeration of the root areas is provided through compost application.

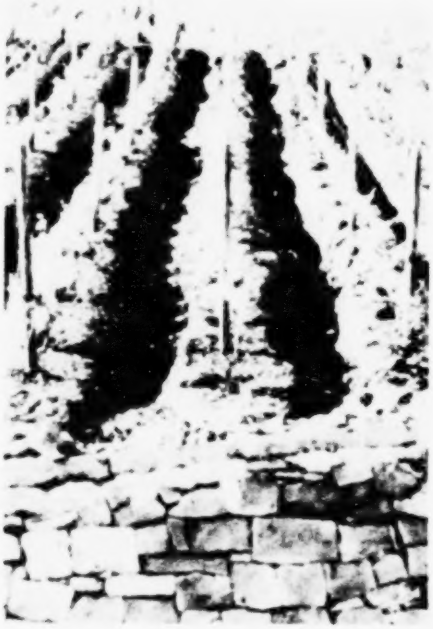

Figure 6. Erosion damage in vineyard

Figure 7. Erosion exposing grapevine roots

Average and heavy soils show improvement in permeability which is of great importance on the vineyard slopes during rainfall. Because vineyards are generally in warm dry climates, it is very important that much of the precipitation be absorbed and water loss from runoff be prevented. Finally, (compost) achieves a loose and relatively stable soil structure forming a more effective protection against erosion.

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NO. 14

APRIL 1962

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A-1

Part III: Processing Technic

1. Practical Conclusions from Scientific Research by

Dr. H. Straub, Director, Municipal Works, Baden-Baden.

The research projects that have been conducted for several years have not given us a complete picture of the problems connected with refuse processing and disposal, but have shown a definite pattern justifying the drawing of some conclusions which can only be summarized here.

In plan preparations for sewage treatment and refuse processing plants, it is necessary to gather all pertinent data on the nature and amount of wastes to be dealt with. Just as successful sewage treatment plants cannot be planned without knowledge of the composition and quantity of sewage, information is also necessary in planning refuse processing plants on the amount, nature and composition of domestic and industrial refuse. Without preliminary investigations which pertain to the local conditions, no decision should be made regarding the processing plant, whether incineration or composting. Determination should be made as to which of the two methods will require the least subsidizing and which will be the cheapest to operate and last the longest. The AkA, in collaboration with the VKF and ATV, has the task of preparing instructions for the uniform performance of such preliminary investigations. The first bulletins of this kind will soon be published by the VKF.

Because extensive analyses have shown that sewage solids and refuse to a large extent supplement each other, it can be concluded that those procedures deserve particular attention which allow common, simultaneous processing of refuse and sludge. If digested or raw sludge has to be disposed of separately, high costs result because it has to be dewatered and dried as it cannot be fully used in agriculture when of a watery or pasty consistency. Thus, if certain advantages exist in joint processing of refuse and sludge, the technics for this should be developed with the aim of eliminating the cost of dewatering the sludge.

Joint refuse-sludge processing can only be contemplated when equivalent amounts per capita can be treated. Recent studies have been aimed specifically at learning how much such equivalent quantities can actually be processed. It should suffice here to start with the values given in Imhoff(1) for the sewage flows per capita. These quantities naturally differ from case to case. Table 1 indicates the daily or yearly amounts of solid matter yielded per capita by various treatment processes and the amounts remaining after sludge digestion. The sludge volumes are based on the usual moisture contents. (Table 1).

A primary treatment plant yields 14.6 kg of solids or 124 liters of digested sludge per capita per year; a trickling filter plant yields 19 kg of solids or 175 liters of digested sludge; and an activated sludge plant yields 22.7 kg of solids or 288 liters of digested sludge. Sludge volumes increase considerably in proportion to the dry weight of sludge in the biological treatment plants. These values are still further complicated by the fact that the digested sludge from biological treatment plants is finer than that from primary plants which permits drying only with considerable technical and financial expenditures.

Concerning domestic refuse, not including industrial wastes, the equivalent amounts are given in the AkA Handbook(2). Here, too, quantities vary by locality and depend on the standard of living and the community structure.

TABLE I

TOTAL AMOUNT AND SOLIDS CONTENT OF COMMUNITY WASTES										
Sewage Treatment		Solids in Sewage Sludge after Imhoff						Sludge Volume		
		g/cap/day			kg/cap/year*			liters/cap		%
		Org.	Min.	Total	Org.	Min.	Total	Daily	Yearly	H_2O
Primary Treatment	Raw	40	20	60 (54)	14.6	7.3	21.9	1.08	395	92 - 95
	Dig.	20	20	40 (34)	7.3	7.3	14.6	0.34	124	87 - 90
Primary Treatment + Trickl. Filters	Raw	50	30	80 (74)	18.25	9.95	28.2	1.48	540	95
	Dig.	25	30	55 (48)	9.10	9.95	19.05	0.48	175	87 - 90
Primary Treatment + Activated Sludge	Raw	58	33	91 (85)	21.2	12.1	33.3	1.87	670	95.5
	Dig.	29	33	62 (55)	10.6	12.1	22.7	0.79	288	90 - 93
Domestic Refuse Quantities after AkA Manual		Solids in Refuse			Total Weight			Total Amount		
		kg/cap/year			kg/cap/year			per cap/year		%
								kg	cu. m.	H_2O
		68	100	168	68	100	224	0.61	0.7	25
							240	0.66	0.7	30
							258	0.71	0.7	35

*With complete removal of dry solids (settleable solids).

It is assumed today that an average of 168 kg (dry weight) of domestic refuse is yielded per capita per year and that this consists of 100 kg of mineral and 68 kg of organic matter. If the average moisture content is taken as 30%, then the total wet weight of refuse is 240 kg/cap/year (Table 1). Total weight per capita per day varies with the moisture content between 0.61 and 0.71 kg, according to the table. At an average density of 0.35 tons (metric) per cubic meter for uncompacted refuse, this gives an average of 0.7 cubic meters per capita per year. Although the volume of refuse per person has greatly increased in recent years as a result of the changed composition of the refuse, the increase in dry weight of the refuse is insignificant.

If the proportions by weight of solid matter of refuse and sludge are compared, there is then obtained:

For a primary treatment plant: Refuse: Digested Sludge = 168:14.6, or 11.5:1

For a complete treatment plant: Refuse: Digested Sludge = 168:22.7, or 7.5:1

Comparing the volumes in the same way, the proportion is:

For a primary treatment plant: Refuse: Digested Sludge = 700:124, or 5.5:1

For a complete treatment plant: Refuse: Digested Sludge = 700:288, or 2.4:1

In the choice of the processing method, there is thus a very decisive factor in that in a mechanical treatment plant considerably less sludge is produced per unit of refuse than in a biological treatment plant. It must be possible to dispose of all the solid matter yielded.

The relative proportions between weight and volume must be considered if equivalent quantities of sewage sludge and refuse are to be treated or disposed of. Preliminary investigations must be made to determine what these equivalent quantities are in order to compute the proportions of solid matter and the volumes requiring treatment. If composting is considered and the proportion by volume is such that anaerobic decomposition would occur, sludge dewatering would first have to be provided in order to adjust to an admissible proportion of refuse and sludge in the mixture. The moisture content of sludge is determined both by the degree of digestion and by the degree of sewage treatment, but it is subject to no significant seasonal variations. Regardless of whether the refuse and sludge are composted or incinerated alone or together, an excessive water content in the sludge would constitute a burden and would increase the cost of disposal.

The moisture content of refuse varies considerably during the year, from about 20 to 45 or 50%. (Fig. 1.) This moisture content decisively determines the subsequent processing. In incineration, it influences combustibility; in composting, a certain moisture content must not be exceeded for biological reasons.

In relation to the yearly average quantity of refuse, the weight of winter refuse is 1.2 times, that of summer refuse about 0.85. In planning a processing plant, it is important to know accurately the quantity collected over at least a year, preferably several years, in order to establish the sizes of mechanical installations. Average annual quantities of refuse can be estimated approximately if measured around May 1 and October 1. (Fig. 2.)

Possibilities for disposal of these wastes consist of either biological decomposition or incineration. In the latter case, the organic content of the wastes is destroyed and only the mineral matter remains for disposal.

The possibilities of incineration of refuse and sludge will be considered first. In the Federal Republic of Germany, the calorific value of refuse is calculated

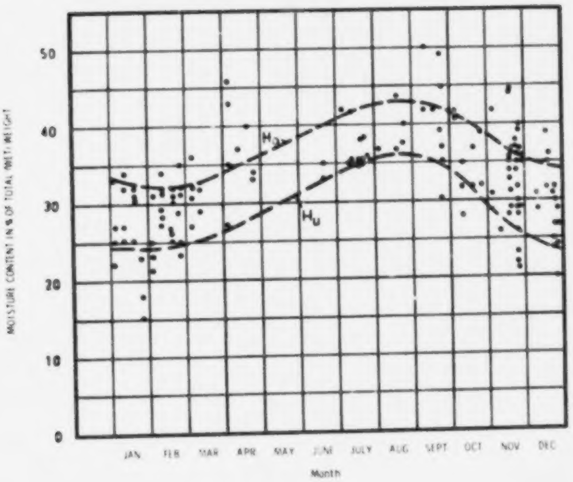

Figure 1. Moisture Content of Raw Refuse at Baden-Baden, 1959-1960.

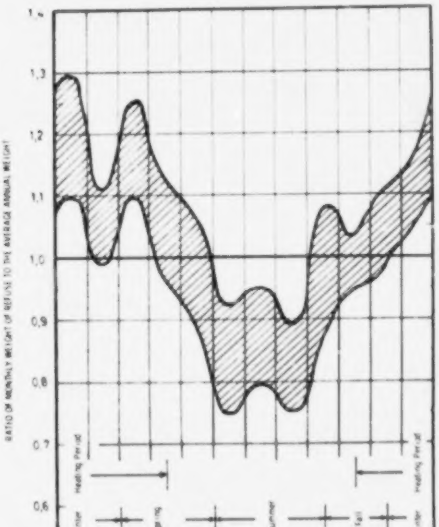

Figure 2. Seasonal Variations in Amounts of Refuse in Western Europe.

at 800 - 1600 kcal (kilocalories)/kg. The assumed value in sludge burning is 3800 kcal/kg of dry matter. If wet digested sludge contains about 93% water, there will be required 1200 kcal/cu m of wet sludge in order to evaporate the water.

Theoretically, complete drying of sludge from a complete biological treatment plant not providing other methods of drying requires 350 kcal/cap/yr. The yearly refuse production of 240 kg/cap will yield an average of only 290 kcal/cap/yr; that is, the available heat energy in the refuse is not sufficient to dry the equivalent production of wet sludge. The remaining 60 kcal/cap/yr can only be provided by burning the dry matter in the sludge itself. In biological treatment plants with a calculated 22.7 kg/cap/yr of dry matter and an energy equivalent of 3800 kcal/kg, the available heat of combustion is 86.5 kcal/cap/yr which just compensates for the heat deficiency required for drying the sludge.

It can be stated that the amounts of digested sludge from a complete treatment plant and the equivalent amounts of domestic refuse can be incinerated together because the available energy in the refuse and the organic matter of the sludge suffice for combined incineration based on the annual average figures. Calculations are still more favorable if the refuse is incinerated with the lesser amount of sludge from a primary (mechanical) plant (drying of sludge at 150 kcal/cap/yr is less than the 290 kcal/cap/yr from the refuse).

The seasonal variations in the refuse collected would, of course, have to be more accurately calculated in order to obtain the heat balance in daily averages. Because of the lower heat value of refuse in winter -- sometimes as low as 800 kcal/kg -- the need for added fuel oil must be considered in order to compensate for the heat deficit of sludge drying. As the refuse is the chief source of heat, it is naturally possible to incinerate refuse alone, satisfying the heat values. But, if it is desired to incinerate sludge alone, additional energy must be provided from other sources.

Incineration of refuse alone is well-developed from a technical point of view. Refuse incineration has a history of 90 years and so there is now only a minimum of risk.

Refuse and sludge incineration plants must operate without creating odors or dust. Combusion gases must be cooled and the installation of electrofilters is necessary to accomplish this. Incinerators should be provided with heat recovery installations. However, it is not always possible to recover all the heat because heat production and the possibilities of recovery cannot always be balanced out. In making comparative calculations of heat return, complete recovery of heat cannot be counted on. The mineral matter remaining as cinders must not be forgotten; it comprises 30 - 45% of the weight of raw refuse and 15% of the raw refuse volume.

Of the composting processes(5), the following distinctions may be made:

I. Composting in windrows without prior grinding.

II. Composting in windrows with prior grinding.

III. Composting in cells without prior grinding.

IV. Composting in cells with prior grinding.

The essential requirement common to all processes is that the compost produced must satisfy hygienic requirements. Pathogenic microorganisms or human, animal and plant parasites must not survive the decomposition process. Recent studies have given us a thorough knowledge of the decomposition processes and enable the establishment of minimum conditions to satisfy hygienic requirements.(3)(4).

Sanitary requirements of refuse incineration are completely met provided adequate filter arrangements exist for the combustion air and the fly-ash is retained.

Digestion of sludge is recommendable as it leads to a reduction of pathogenic microorganisms and reduced germ counts. Digested sludge should be used in agriculture only if it is free from harmful substances (poisons, radioactive material) and if provisions are made to eliminate direct transmission of pathogens it might contain to man and animals.

The use of raw refuse is subject to criticism from a health standpoint, especially if it is mixed with or wetted with sludge. Even in filling hotbeds, there is no assurance that pathogens will be eliminated and that no contact contamination will be possible. Non-spore-forming pathogens remain viable for a long time in refuse, the pathogenic spore-formers are not affected at all under these conditions. This subject is covered in the AkA Handbook.

Composting of these wastes affords sufficient assurance in hygienic respects, if it occurs over at least two weeks at a temperature range between 55 and 60°C at a moisture content of 40 - 60%. Such is the case when aerobic decomposition is established and anaerobic conditions are avoided.

It has been learned from completed research projects that a multitude of bacteria, actinomycetes, molds, etc., participate in the processes of decomposition which transforms the organic matter of the refuse. They multiply rapidly when favorable conditions for decomposition exist. If conditions are aerobic, the temperature increase is a sign of the biological transformation.

Carbon dioxide is a product of metabolism of this activity, the process occurring more intensively the closer the C:N-ratio of the raw refuse lies to the C/N of the active organisms. In this connection, there are active organisms in the mesophilic as well as the thermophilic phases of decomposition. The temperature has to be prevented from rising higher than 60° C, by regulation of the decomposition, to avoid overheating and resultant damage to the functioning of the microorganisms (6).

If care is not taken to provide sufficient atmospheric oxygen, completely anaerobic conditions can occur. External indications of this are foul-smelling organic acids and hydrogen sulfide. Methane is formed only when air access is completely cut off, changing the process from rotting to digestion such as occurs in sludge digestion. Under such conditions, little or no heat is generated.

Composting is an aerobic process in which aerobic conditions should prevail. The composting material should contain at least 40% moisture but not over 60% because the organisms can obtain their nutrients only in fluid form through the cell walls. If moisture is less than 30%, the process of decomposition ceases. When moisture is above 60%, stoppage of the air pores occurs and a certain amount of open air pores is necessary for supplying sufficient oxygen (7). The upper limit of moisture also depends on whether only water is added or sludge is the wetting agent, and upon whether the raw material was pulverized before composting and the resultant pore volume was initially reduced. In such case, the upper water content limit may be only 50%.

Experiments have clearly shown that the addition of primary digested sludge is possible in equivalent amounts if the refuse has not been ground. The greater quantities of sludge from a complete treatment plant have to be dewatered to a thick, viscous consistency (about 78% on drying beds) if it is to be added in full to the coarse refuse. But, if the refuse is ground before composting, anaerobic zones will then tend to occur even without the addition of sludge. The addition of sludge usually necessitates further dewatering or drying to such an extent that the moisture content of the mixture does not exceed 50%. Present technical possibilities for dewatering sludge and the financial expenditures required make this problem particularly difficult to solve. To date, the only satisfactory sludge dewatering has been done on vacuum fitters, with and without auxiliary beds. In addition, the heat drying of sludge should be mentioned as practical in processes where there is a narrow range between upper and lower limits of moisture because of pre-grinding of the refuse.

Niese has proved that, with the occurrence of anaerobic conditions during composting, a complete retrogression of the aerobic microflora ensues. There results an interruption of the biological decomposition, a decrease in self-heating and an increase, after a delay, beginning only if aerobic conditions are restored and the aerobic flora can still develop or return. They can develop only if there is sufficient decomposable matter available.

High temperatures are not the only cause of destruction of the pathogenic organisms as it is clear that certain inhibitory substances also develop during decomposition which produce the effect of biological self-purification. According to Strauch (6), even the anthrax bacillus, considered the most resistant of bacilli, is destroyed on maintaining the described composting conditions. When composting is conducted at too low temperatures (cold composting) or anaerobic zones of digestion develop, self-purification does not result and hygienic requirements cannot be fulfilled.

It is certain that the most favorable and rapid decomposition occurs only under aerobic conditions. The decomposition can be improved if nitrogen in the form of bacterial nutrients is introduced and the C/N thereby decreased. In this way, losses of carbon and nitrogen can be avoided and the composting process is accelerated. For these reasons, the composting of sludge and refuse together can be recommended.

The most recent research results on these biological processes raise certain requirements for technical processing methods, as follows:

(a) Joint composting of refuse and sludge is sensible not only because of the possibility of sludge disposal but also for biological reasons. By such composting considerable savings may be made in dewatering sludge but the composting of equivalent quantities must be possible.

(b) In windrow composting without refuse grinding (process 1), sludge can be added because the coarse refuse matter assures sufficient aeration pores. Yet the material should be turned at least once and this after only a short time. The coarser the refuse, the more sludge may be added to the upper limit of the permissible moisture content. The upper moisture limit for unground refuse and sludge is 60%; for ground refuse, however, it is 50% but it is influenced by the content of moisture-absorbing materials such as paper or fine refuse particles. Generally, refuse containing the most organic matter is more capable of absorbing water than refuse with a high mineral content. The above limits for moisture are only valid for the present quality of refuse in Central Europe.

(c) In contrast to (b), if the raw refuse is ground before composting (process 2), safeguarding the maintenance of aerobic conditions must be made by turning the piles several times, particularly during the first weeks of composting, to facilitate the entrance of oxygen into the piles. This can also be done by installing aeration channels or by forced aeration. When refuse-sludge mixture is composted, preliminary grinding should not be carried too far because the sludge addition reduces the relative pore volume. Pregrinding should only be carried out to the extent necessary to separate out the hard particles. The microorganisms do not profit from pulverization if the entrance of air is thereby hindered and they are thus destroyed. But pulverization is advantageous in separation of hard particles. Pre-grinding renders refuse more easily freed of inorganic materials by centrifugal (ballistic) separation. It is thus preferable to subject the refuse to processing before adding the sludge.

(d) In enclosed cells (processes 3 and 4) the supply of air can be regulated at will. The air supplied must be sufficient to avoid the formation of anaerobic zones. The question of air supply merits more attention when refuse and sludge are composted together. Great care must be taken to see that all cross-sections of the cells are adequately supplied with oxygen to prevent formation of anaerobic pockets. Strong disagreeable odors may arise if anaerobic zones form because of discharge of circulated air to the outdoors.

(e) Hygienic requirements can be fulfilled in decomposition cells under completely aerobic conditions only if the prescribed decomposition time is employed. If the time is inadequate, then subsequent decomposition in open windrows is required which must go on aerobically at least during the first days. The compost leaving the cells has undergone only the first stages of decomposition of the organic matter and rots some more. It is therefore improper to expect completion of the decomposition in 2 or even in 5 days as has been occasionally stated.

(f) The addition of sludge is made according to the optimum moisture content permissible during composting. Under certain conditions preliminary dewatering or drying of the sludge is necessary. The temperature of decomposition can be adjusted by regulating the moisture content in the raw refuse so that temperatures over 60° C that are injurious to the microflora can be avoided. The moisture content of the raw refuse determines the amount of water that should be added as sludge in order not to exceed the optimum moisture content of the mixture and create anaerobic conditions. Control of moisture content is an important aid in maintaining the optimum temperature of decomposition.

(g) Decomposition should proceed for at least two weeks at 50-55°C in order to fulfill the hygienic requirements of composting. Additional composting under aerobic conditions is not necessary because additional destruction of organic substances would occur which are better decomposed in the soil. Anaerobic conditions may be created at this time, causing interruption of the decomposition of organic matter. Windrows can be done away with and the compost placed in high piles until it is to be used. The lack of air in the high piles reduces organic matter decomposition which is saved for occurrence in the soil. A better means of preventing further decomposition of organic matter, however, is by drying which can be achieved by intensive aeration. The moisture content sought should be 25 to 30%.

(h) The cost of sludge dewatering represents a considerable part of the costs of plant operations. It is not sensible to provide preliminary grinding of the refuse with the expectation that the decomposition will be more rapid. This expectation is not fulfilled not only because of inadequate air supply but also because of the higher costs of sludge dewatering. There must be a reasonable balance between the desirability of separation of inert matter, which is aided by pre-grinding, and the need to establish aerobic conditions of decomposition. The more thoroughly the refuse is initially pulverized, the more completely must the sludge be dewatered in order to avoid such anaerobic conditions.

These conclusions drawn from research projects must be considered now and in the future for both the mechanical equipment of the processing plants and the composting itself. Inevitably some systems will have to be changed. If scientific research is to have meaning, processing technics must make use of its findings. Almost all composting processes to date have been based on intuitive considerations and empirical data, and it is very welcome when new knowledge results in improved processing technics and leads to better procedures. At the same time, research should help clarify processes that have not always been clearly understood even by specialists in the field.

When we reflect that in 90 years of development incineration has attained a high stage of technical development, it is not surprising that procedures for composting are still just beginning. Scientific research and a growing knowledge of the complicated processes of composting will help reduce this lead more and more. We believe that information published in the present reports will contribute to the improvement of processing technics for composting.

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2. Technical and Practical Results and Developments in Refuse Processing and Composting by O. Horstmann, Municipal Works, Heidelberg.

The managers of many composting plants have exchanged experiences for 3½ years and it has been possible for them to clarify many concepts in their field of interest during the course of 8 meetings. More criteria have been shown to be satisfactory than was originally expected. Yet many questions still remain unsolved and developments continue. It can be asserted, however, that none of the composting plants put into operation have had to be shut down but, despite initial difficulties, the plants have overcome them and been able to function satisfactorily in all cases.

From these collected experiences the following points can be reported and their influence on further developments investigated:

1. Hygienic requirements.
2. Refuse quantities of different composition.
3. Seasonal and yearly variations.
4. Distribution problems and selling prices.

These points will be treated separately even though they are interrelated.

First, however, an explanation of concept: Distinction should be made in the complex subject of refuse treatment between refuse processing (i.e. screening, sorting, grinding or homogenizing) and the composting. The two procedures are naturally interwoven but, whether we intend to compost all of the refuse or not, it should be systematically processed for hygienic reasons.

Hygienic Requirements: -

The hygienic requirements are foremost in all refuse and refuse-sludge processing and will remain so. They are thus accorded an ever greater place in research studies and are placed first here. Hygiene is a very broad term and I will use it here in its broadest meaning.

Hygienic and esthetic reasons, together with inadequate space, compels us to give up the method of refuse dumping inasmuch as the dumps pollute ground water and are nuisances because of dust, flying papers and ashes, proliferation of vermin, noxious odors, and fire hazards. Composting and incineration plants being built to replace them no doubt represent real progress. Hygienic requirements still arise; not only must these installations eliminate all hygienic hazards, such as the destruction of pathogenic organisms, worm eggs and weed seeds, but they must not create new ones such as dusts, odors, or air pollution as from incineration. Finally, care must be taken to insure hygienic working conditions in the plant, particularly in refuse sorting and in handling the screenings.

Technical problems are many in composting plants because they concern transformation of heterogeneous material of extremely variable composition into compost and at the same time observing all the requirements of hygiene, safety and mechanical functioning. This applies to all sections of a plant and there are many places for blockages and spills along conveyors and at receiving or delivery points, making the work difficult and unpleasant unless operations are well-organized. The precise manner in which the solid residues are removed is a good criterion for evaluating the plant. Good coordination of all functions will permit smooth operations as previously determined by rational design of the plant units. Meeting these hygienic requirements of course costs money but it is essential that they be observed without exaggeration. Expensive buildings are no guarantee of hygiene; it is essential that they be primarily adequate and functional.

Big business is also taking an increased interest in the processing of refuse. Even well-known firms in the mining industry have become interested. Unfortunately, they are often dissuaded when they see the complex unsolved problems and learn that processing the wastes is not all but that composting with its biological problems is also necessary. We hope that many companies with their special knowledge will participate and pool their specialized equipment so that equipment development will be widely distributed in spite of the small number of installations of this kind. Of more significance is the noteworthy progress already achieved by the firms which have been concerned with refuse processing for a long time, and I gladly take this opportunity to mention some of these developments.

An apparatus for washing and oxidizing the discharge air for Dano plants has been developed. The exhaust air, after removal of mechanical (sic) contaminants, is treated in a 3-stage jet washer with chlorine dioxide.

The Dorr rasping machines (refuse treators) are now being made in an improved form in Germany, and this will make it easier to get replacement parts.

Manufacturers of double-rotor mills report that certain improvements have led to considerably reduced wear and tear without restricting the degree of pulverization. In addition, the grinder capacity has been increased by automatic adjustment of the segments with less energy and wear. By screening and reprocessing the residue a sufficiently fine-milled material can be obtained.

A safeguard against damage to the machines has been developed in the form of a high frequency sorter, said to protect the hammermills against large pieces of light metals, copper and non-magnetic metals.

Some very large furnaces have been built to incinerate the waste matter and are capable of burning large, dense and compact or wet wastes. To achieve more uniform distribution on the furnace grates, the scraps can first be passed through a roller mill, pulverizer or hammermill. Such a hammermill with an inlet 1.5 X 3 meters is soon to be built, but smaller units have already been constructed.

Refuse Quantities of Different Composition: -

It is false to assume that simple enlargement of a plant suffices for processing larger amounts of refuse. There is a very great difference between production of 1,000 and of 10,000 cu. m. of compost. The quantities effect all parts of the composting operations, including machinery, conveyors, sanitation and compost sales. Variations in refuse composition act in the same way. For example, during a winter cold spell after a holiday, the trucks will deliver double the usual amount of refuse with a high ash content. Can the plant receive and process this unusual amount of refuse? If at the same time there is a heavy consumption of compost, all sections of the plant should be working at peak capacity. The same can occur in the spring when refuse may contain masses of old clothes after spring housecleaning, or an abundance of grass after the first mowings of lawns. We must therefore warn against designing the plant on the basis of average figures, particularly when they are derived from a limited amount of data.

Predictions about future variations in refuse composition are generally too pessimistic. At Heidelberg they have greatly reduced the effect of newsprint on compost. There are just as unfounded fears about poisons in domestic refuse. Also, the increase in plastics is not a great cause for concern; the large pieces can be removed and the smaller ones shredded or pulverized.

Old clothes are and will remain a detriment to any form of processing, particularly nylon hose which have increased from 9 to 15 pairs per woman per year.

Seasonal and Yearly Variations: -

It is well-known that the composting process depends upon careful maintenance of proper moisture and oxygen contents. The longer composting occurs outdoors, the greater the influence of the weather. An interesting observation is that rain does not penetrate deeply into the windrows early in composting, probably because of the fungi that develop in the outer layer. The riper the material becomes, the more permeable it is to water. Moisture penetration is unfavorable at this stage because the material loses its friable structure, becomes packed, and may become anaerobic. Heavy rains this spring severely damaged the compost piles (150 mm in June of which one-third fell in one week). Then, if the sun shines on wet compost, the eroded and relatively inactive top layer dries out while the compost beneath remains too wet for weeks. Only after two or three turnings does the condition of the material improve a little.

It is thus clear that the site for composting piles must be well-studied before selection is made. Not only should it be on firm ground, but it should slope to permit rapid runoff of rain and seepage water with proper ditching. Also, open space should be provided between compost piles so that water will run off and not soak into the piles at the base.

It is preferable to provide cover for the second stage of composting as is done at Jersey and Baden-Baden. To be entirely independent of the effects of weather (but not solely for this reason), some types of construction were recently developed which I have described and illustrated in the journal "Der Städtetag."

The Effects of Distribution Problems and Selling Prices: -

As far as I know, the sale of compost has not developed at any compost plant according to plan, even when distribution problems were thoroughly studied and when there was advance assurance that the compost could be sold. But new possibilities for marketing continue to be discovered and no plant has ever had to close for lack of sales. Anticipated sales should indeed be thoroughly studied and tested, but plans need not be abandoned for a composting plant if preliminary calculations do not show complete sales. Then it would be better to hire a good sales manager for the plant. This is cheaper than having to haul away unsold quantities.

It is desirable to have another outlet for compost sales in any case. There are always seasonal and yearly conditions that make selling difficult. Nothing is worse than being overloaded with open, deteriorating compost piles in which the compost is too old for use and it no longer pays to process it. It is better to have a wholesale contract or to discard this compost on wasteland to render it arable, than to have a forced sale of the overage compost.

We hope that still other solutions will be developed for these problems. Some day it may be possible to speed up or slow down the composting process at will, or to render the materials more suitable for storage in either the raw or finished state. These are not vain hopes. A few additives for accelerating the composting are already known. They need not necessarily act by increasing the microorganism activity. Additives may also be developed to inhibit the activity of some undesirable thermophiles, making the decomposition easier for the mesophilic organisms. Or, the decomposition process may be interrupted by drying at any period, whether initially or at peak activity. Or, it may be possible to achieve stabilization by adding fungi to render the compost fit for storage or even bagging.

All these measures would prevent the need for forced sales of compost whether they result from excessive refuse collection or compost production. Sales could then be adjusted to the seasonal demand and production could include either regular or refined compost according to demand. The previously mentioned rotting test could be applied to the compost to make available the best product to the consumer.

Much research and development are still needed in conjunction with existing composting plants. Lesser importance is given in this to the methods of processing and of composting than to whether the plant and management are capable of adapting themselves to the various requirements of hygiene, fluctuating quantities, weather conditions, and consumer demands, in short to all conditions prevailing in practice.

This adaptability is also required even for a very loose cooperation between the composting plant and those marketing the products. Such collaboration is considered desirable for compost plant managers if only to expand publicity and consultation. They could employ a good agricultural advisor to visit various types of growing areas to encourage compost sales by means of demonstrations, conferences and exchange of experiences. Each plant would pay a proportion of the fees based on production and thereby approach the concept of a central compost station.

In such a cooperative scheme, the uniformity of the composition and properties of the material would play a large role. These are also very important for the individual plant desiring to acquire a permanent list of customers. There is for this reason a need for continuous control of operations in Germany; that is, for a series of standard methods of analysis permitting plant control and comparison. A special committee on "Operational Control" has been set up to work out these standards under the leadership of Chairman Andres, Bad Kreuznach. This committee has already prepared recommendations, with the help of soil analysts, which will be published when approved by the main committee. The subcommittee will also publish a collection of methods. The aim is to establish the test for compost which has been long awaited. I hope the task will be accomplished soon and the test for compost will become generally known and widely applied.

Financial Problems: -

Those responsible for individual plants and for the system as a whole cannot ignore the question of economics. Comparisons of costs and also of yields have frequently been discussed at our meetings. However, it has been very difficult and time-consuming to break down operational costs of existing plants into the types of expenses applicable to modes of operation which vary from plant to plant. It is just as difficult to find a common denominator in terms of output because one plant may not be at full capacity, a second may have been interrupted in summer, and a third may have been interrupted in winter. A fourth plant may have stopped operations for enlargement or improvement, and this does not exhaust the possibilities. We have chosen the normal yield of a plant, in terms of (metric) tons of refuse, in which plant operation is stopped only for routine repairs.

Annual financing of a costly plant is important in determining costs of operation even though the method of evaluation differs from city to city. However, with the present personnel shortage, the tendency towards shorter working hours and demands of manual labor, it seems best to use all possibilities to replace manual labor by machines, even though this increases the capital expenditures, interest and amortization. These costs are largely compensated for by savings in salaries and non-dependence upon workers.

Future Developments: -

Along with a reasonable increase in mechanization, we strive for a controlled process of decomposition, permitting processing of refuse only, or of refuse and sludge, on as small a site as possible and with the least detriment to the neighborhood. Plants will be more adaptable to producing, according to market requirements, either a high-grade compost for market gardening or an ordinary compost suitable for mulching, sheet composting, reclamation of wasteland or, if necessary, for use as fill without danger, just as with incinerator ashes. Finally, a method of treatment will be developed which permits compost transportation to distant areas where demands are greater.

We believe that, when these signs of development are properly interpreted, we will be entering an era in which progressive research at a few scattered plants can foretell development of better methods leading to the maximum returns from the wastes. In this era we may expect greater participation by individuals, businesses and organizations interested in work so important to the general welfare.

3. Dewatering and Drying as a Prerequisite to Composting of Sewage Sludge by Dr. W. Schröder, Viersen.

In the preface to the manual of the AkA it states that the main task of the working committee consists of seeking ways to dispose of solid domestic wastes, either by destruction or transformation within the cycle of nature. These community wastes, both solid and liquid, insofar as they do not contain toxic contaminants, become good humus fertilizers after undergoing certain types of treatment. It therefore appears highly desirable to pursue lines of research aimed at completing the natural cycle of transformation.

Good results have already been achieved in this respect regarding refuse. Another possibility consists of composting refuse and sewage sludge together, which has already given excellent results.

There exist various possibilities for refuse-sludge composting:

(1) Liquid sludge directly from the digesters may be added to the refuse, but only a part of the sludge can be used because of its high moisture content.

(2) If sludge is dewatered to a moisture content of 70-75%, it is then usually possible to process all sludge and all refuse of a given community.

(3) The sludge may be further dried by appropriate methods and added to ground refuse prior to composting.

The methods for dewatering and total drying of sludge before mixing with refuse will now be reviewed.

In recent years the problem of processing sludge (i.e. its drying and disposal) has become one of the most urgent problems in sewage treatment. Discharging sludge into drying beds or lagoons, and the resultant slow drying that is largely dependent on the weather, is impractical for large plants. Mechanical means of dewatering and drying are more and more sought after when, because of the large quantity, wet sludge cannot be distributed on farms.

The intense study of sludge processing today indicates that the problem was not properly recognized formerly. This is, without doubt, untrue. The importance of these problems was clear long ago. It was then easier to dispose of the smaller amounts of sludge produced and sporadic attempts to use mechanical procedures probably ran into difficulties; thus, in former days, return was generally made to drying beds and lagoons. These procedures are no longer adequate because of lack of available land and the constantly increasing cost of labor. It is becoming more and more urgent to find a solution to the problem of sludge handling. Considerable progress has been made in other countries, particularly the United States of America, in mechanical sludge dewatering and drying. For economic reasons, however, these procedures cannot be directly transferred and applied to our conditions.

After many experiments, the Niersverband in 1953 decided to dry sludge artificially from central plant No. 1 at Mönchengladbach and Rheydt. In this system sludge is first dewatered by vacuum filtration then further dried as needed in heated rotary drums. This procedure is technically satisfactory but it would be desirable to reduce the costs of filtering (due to the cost of chemical conditioners) and of drying (due to fuel costs). It might be added that sale of sludge dried to 35% moisture and sold as "Humusit" has so far run into no difficulties. The demand exceeds the supply. Many tests have been made by many organizations, institutes, and cities to develop an economical sludge drying procedure and are summarized below.

1. Sludge Sieves

Trials were made with the Heimann, Russel, Rhewum and Edco sieves (fine, vibrating screens). By this method, 50 to 80% of the solids are removed depending on the particle size of the initial sludge. The effluent is a thin sludge of fine particles, containing 2 to 5% solids. This sludge is difficult to process and may not be discharged untreated. But returning it to the treatment plant influent should also be avoided.

2. Sludge Centrifuges

Trials were made of bowl, decanting and horizontal centrifuges. In this process, too, the centrate contains 2 to 4% of extremely fine solids with the same difficulty of treatment as with sieves. In these two procedures, the effluent comprises 70 to 90% of the original quantity depending on the degree of solids concentration. It is a real problem to know what to do with this thin sludge that is only slightly less in quantity than the initial amount and is difficult to process. A trial of drying this centrate in Detmold drying plates gave very short drying times but this can be regarded only as an exceptional, not as a conclusive result (Starcosa procedure). (See Fig. 3)

3. Sludge Filters

The principle of all filters is the same: the separation of solids and liquid by means of a heavy fabric, fine tissue or a porous ceramic plate, the so-called filter medium. The difference in pressure on the two sides of the filter operates the filter-high pressure above, low pressure below, or a combination of the two. Most of the water in the sludge is aspirated or pressed through the filter while the solids (filter cake) remain on the filter medium. (See Fig. 4 and 5)

(a) Vacuum filtration is widely used, especially in the United States. Unfortunately, normal settled sludge is not easy to filter unless it has been carefully pre-conditioned, that is, mixed with coagulants, which considerably increases costs. The procedure has the advantage of operating continually and completely automatically, and it produces a clean filtrate which can be permitted without trouble to be discharged into the plant effluent.

Attempts have been made to dispense with the coagulants by filtering the sludge through an auxiliary layer over the usual filter cloth - the precoat process - but this is not always successful and is scarcely cheaper than the usual vacuum filtration. It remains to be seen how favorable the results are in the new procedure with inmixing of ashes - from burnt sludge - in filtration (procedures according to Lurgi and to Wegmann).

Vacuum filters consist of cell filters, cell-less filters and disk filters. The differences between them need not be discussed here.

(b) Pressure filters are also made in various designs. They have proved particularly suitable for dewatering sludges high in mineral content. An example of this is the sludge at the Emscher sewage treatment plant in Carnap. (See Fig. 6)

The above processes are only good for preliminary dewatering of sludge. To reduce the moisture content still more so that it can be spread (on land) or, if necessary, burned, supplementary measures must be taken that will be reviewed later.

Two processes might be mentioned here that also require preliminary dewatering but which render additional treatment unnecessary. These are the Fige and the pressure-drying process.

(a) The Fige Process - In this procedure the Fige-filter-generator, developed by the Emscher Company, the sludge is not digested but the raw sludge is subjected to the following successive treatments: (1) dewatering, (2) drying to 20% moisture content, (3) briquetting, (4) gasification in a gas generator. The gas produced, about 1100 kcal/cu m, can be converted to electrical energy.

(b) Pressure-drying Process - Thorough trials were made of sludge drying by the pressure-drying process of Prof. Pöpel. As an example of this process, sludge filter cake is mixed with dried sludge of 10-20% moisture content in an amount resulting in a paste having about 45% moisture. The paste is pressed into bricks which were 16x16x30 cm in this experiment. To increase surface area, small lengthwise groves were formed in the bricks. These bricks are dried in the open or a wind chamber. When the bricks are broken up, a crumbly soil-like product results which can be easily distributed.

Sludge which contains toxic industrial wastes and cannot be used in agriculture must be incinerated. Another disposal method for sludge is the spreading of digested sludge on land from a tank truck. This is undoubtedly the most economical sludge disposal method but it can only be used where the required cultivated fields are available.

The above processes are the most important possibilities for sludge handling. The choice of method is difficult to make because local conditions, sludge composition, sale possibilities, etc., are decisive.

It is concluded that the only dewatering procedure that can now be recommended for normal sewage sludge is vacuum filtration. It is the only process that has been proven satisfactory at many plants and in which the various makes have been time-tested. Whether it is justifiable to digest sludge before dewatering or to deal at once with raw sludge will not be decided here. Instead, I refer to an article in Gas - und Wasserfach, No. 50, Dec. 1960: "Ist die Ausfaulung des Klärschlammes überflüssig geworden?" (Has digestion of sewage sludge become unnecessary?). In sludge-refuse composting, the addition of raw sludge unquestionably results in a better final product than the addition of digested sludge.

The above statements naturally do not exclude the drying of digested sludge on drying beds, particularly in the smaller plants. Only calculations of costs and yields will permit determination of the amount of sludge that may make artificial dewatering practical.

Costs of Sludge Dewatering

If refuse and sludge are composted together, the total yields of refuse and sludge from a community can only be processed if part of the water is previously removed from the sludge before it is mixed with the refuse - that is, the sludge must be dewatered.

An idea of costs is given based on vacuum filtration at the Niersverbandes central plant No. 1: Operating costs for an amount of filtered sludge-refuse of 80,000 - 90,000 T/yr were about 2.50 DM/T (German marks per long ton) of incoming sludge. Based on 6% interest and a 15-year life for mechanical installations, capital expenditures amount to about 10.2% of the capital outlay of about 900,000 DM, or 1.06 DM/T of incoming sludge. These capital expenditures will be somewhat lower in a new plant, about 0.70 - 0.75 DM. Amortization of the buildings of 2,000 cu m volume and 140,000 DM construction cost in 25 years amounts to 7.8% or 10,900 DM. This adds a charge of about 0.13 DM/T of incoming sludge. Thus, including amortization, the filtration costs are 3.69 DM/T of incoming sludge. These figures are, of course, not valid for all sewage treatment plants -- costs will undoubtedly be higher for plants processing less sludge and lower for larger plants.

Subsequent Treatment of Dewatered Sludge

Excepting the Fige and pressure-drying processes, the above procedures reduce the moisture content to about 70%. The sludge paste obtained contains too much water for transportation or utilization. A drier product, containing about 30-35% moisture, is needed for easy distribution. Several methods of preparation exist for this:

(1) Mix the sludge paste with enough dry material, such as peat, to obtain the desired dryness.

(2) Mix the sludge paste with one part of dry material and compost the mixture.

(3) Add the sludge paste to refuse and compost them together.

(4) Heat dry the sludge paste.

The fourth process deserves detailed examination. The main types of heat drying installations are:

(1) Rotary drum dryers: A drum dryer consists of a rotating cylinder, slightly inclined from the horizontal, through which simultaneously pass hot air and the product in the same direction. The drum rotation causes:

(a) the material to be transported continuously from one end to the other, and

(b) the material to be subjected to continuous stirring and thus to be well-mixed with the warm air or hot gases. (See Fig. 7)

The drying air passing through the drum is in continuous intimate contact with the material, assuring an optimum exchange between the moist material and the hot air or gases. Retention in the drum is about 45 minutes. There is an adjustable discharge valve that permits regulation of the drying time or retention of the material and of the air. The discharge end is tightly fitted into a housing with an exhaust vent which discharges the vapor-laden gases into a dust extractor and thence to the atmosphere. Dried sludge drops out beneath.

(2) Honeycombed Band Dryer: The honeycombed band dryer, developed by the Buckau-Wolf Co. of Grevenbroich, is of very interesting construction. The material is transported on an endless band conveyor running vertically. Sludge or sludge paste is pressed into the honeycombs (pockets or perforations) of the band by entrance rollers The moist material is supplied directly from the rotary filter in front of the dryer by means of conveyor belts or screw conveyors, or occasionally through a pipe by means of pumps built for pumping semi-solids. The honeycombed band then passes into the drying chamber, consisting of two hollow walls opposite one another and provided with nozzles. The nozzle openings on both sides are directed perpendicularly to the conveyor surface. Drying air is blown onto the filled conveyor belt. The perpendicular air stream from the nozzles causes severe turbulence at the spot where it strikes the material surface, transferring heat. Because of the continuous movement of the band, the material is repeatedly bathed by drying gases which are continually replaced and which afford the greatest potential for absorption of vapors. Drying time is considerably shorter than that for rotating drum dryers. The use of a short vertical conveyor band offers structural and special advantages.

Heating of the honeycombed band dryer can be accomplished directly and indirectly with fresh air and with waste gases. Any type of fuel can be used as a heat source. The drying air is usually partly recirculated through the heater with only a small portion being permitted to escape to the atmosphere as used gas saturated with moisture insuring a high degree of thermal efficiency. The dry material falls, nearly free of dust, in the form of tablets or pellets. It can then be used as is or after passing through a pulverizer. In most cases with this process, costly apparatus for dust removal from the used air may be omitted.

(See Fig. 8)

(3) Selective Dryer: The Niersverband has conducted experiments with a selective dryer which can be instantaneously assembled for evaporation of 3,000 kg/hr of water. It is a suspension dryer which provides rapid drying of dewatered sludge. The advantage of this process is that the sludge is uniformly dried and deposited in finely divided form which does not require pulverization.

For proper operation it is recommended that the sludge be previously dewatered to about 70% moisture content for which there are well-known tested processes. The dryer should be fed uniformly moist sludge. As sludge is not usually uniformly dewatered, it appears desirable to first transport it to a measuring bin which serves both for storage and for feeding the sludge in a band of uniform width and consistency.

A special apparatus conveys the sludge in finely divided form to the stream of hot gases rising in the dryer. A cyclone collector, started afterwards, separates the waste gas from the finely-divided solids which leave the dryer in crumbly form in a bucket conveyor. Sludge moisture content can be varied between 10 and 50%. A combustion chamber with combined oil-gas heating can be installed for heating the dryer.

(See Figs. 9 and 10)

(4) Stage Dryer: This dryer consists of a number of circular disks, mounted a short distance above one another, which are provided with radial slots. The moist material is added at the top stage from which it is dropped to stages below by means of scrapers attached to the central rotating axis and through the slots until the desired degree of drying is achieved upon reaching the last stage. The hot gases flow countercurrent to the material. The Büttner Company of Krefeld-Uerdingen provides a stage dryer with additional sliding ventilators which are fitted perpendicularly to the axis of the apparatus. This so-called turbine dryer aspirates the hot gases from each ventilator, forcing them to the next lower stage and thus achieves a good yield. It provides careful treatment of the drying material, not particularly important in sludge drying.

(See Figs 11 and 12)

(5) Belt Dryer: An endless belt (conveyor) runs through a chamber traversed by hot gases. The material on the belt is thus dried to the desired degree. The apparatus is not suitable for sludge drying and is only mentioned here for completeness.

Installation Costs of Various Dryers.

Dryer capacities are based on the volume of water evaporated per hour. Installation costs will be compared of two large dryers of 1,500 and 3,000 kg/hr capacity. Prices are f.o.b. plant, excluding shipping and assembly.

Evaporation of 1,500 kg/hr of water corresponds to the drying of about 2,600 kg of sludge with initial moisture of 75% to a final moisture of 40%. Evaporation of 3,000 kg of water corresponds to the processing of double the amount of sludge, or 5,200 kg. In the following table the energy and heat consumptions by the various types of dryers are shown as given by the manufacturers.

Type of Dryer	3,000 kg/hr Capacity			1,500 kg/hr Capacity
	Cost, DM	Energy, KW	Heat required kcal/kg H_2O	Cost, DM
Drum Dryer	260,000	90	935	-
Honeycombed Band Dryer	220,000	20	880	-
Selective Dryer	140,000	90	935	105,000
Turbine Dryer	240,000	20	980	160,000

The higher power requirements of the drum and selective dryers are due to the large air flows peculiar to these types. Specific heat requirements are actually greater in practice because entirely favorable conditions are seldom maintained. We suggest 1,050 - 1,100 kcal/kg of water to be evaporated.

Costs of Heat Drying.

The Niersverband central plant No. 1, where heat drying of sludge has been conducted for years, reports on these costs. Filters dewater 86,000 T/yr of sludge with an average solids content of 7%. The tonnage is increased from 86,000 T to 96,000 T by the addition of about 40 l of ferric sulfate and 80 l of slaked lime solution per ton of sludge.

After filtering to a moisture content of 74%, there remains a filter cake of:

$$96{,}000\ \frac{7}{26} = \qquad 25{,}900\ \text{T}$$

After further drying to 42% moisture content, there remains:

$$25{,}900\ \frac{26}{58} = \qquad 11{,}600\ \text{T}$$

there having been removed: $14{,}300\ \text{T}\ H_2O$

Based on 250 working days and 24-hr operation, evaporation is:

$$\frac{14{,}300}{250.24} = \qquad 2{,}390\ \text{T/hr}\quad H_2O$$

Cost of fuel oil to evaporate one tone of water is:

$$\frac{1{,}100{,}000\ \text{kcal}}{9{,}600\ \text{kcal/kg}} \times \frac{76.10\ \text{DM}}{1{,}000\ \text{kg}} = \qquad 8.70\ \text{DM}$$

Yearly costs for oil will then be:

$$14{,}300\ .\ 8.70 = 124{,}410\ \text{DM}$$

Other yearly costs for salaries, pension fund, repairs, tools, electricity, oil, grease, etc., are: 104,400 DM

Total cost of heat drying: 228,810 DM

Installation Costs and Capital Expenditures.

In illustrating capital costs, we will not use the example of the central plant No. 1 installation but a modern selective dryer with a capacity of 3,000 kg/hr of water. If the sludge is to be sold after drying, the purchase of a second, reserve, dryer is needed.

One dryer, assembled, including the furnace and all accessories, costs: 200,000 DM

Life expectancy is 10 years.

Special requirements are 1,300 cu m; one cu m of building space costs 60 DM = 78,000 DM

Upon installation of 2 dryers, operating alternately, the life expectancy of the two is 15 years.

Capital expenditures at 6% interest amount to:

400,000 . 10.3% = 41,200 DM
156,000 . 7.8% = 12,168 DM
53,368 DM

Annual costs of heat drying:

Operating costs 228,810 DM
Capital expenditures 53,368 DM
Total 282,178 DM

Cost per ton of sludge treated:

$$\frac{281{,}178}{86{,}000} = \underline{\underline{3.27 \text{ DM}}}$$

As already stated the reserve dryer is only needed if sludge is sold. Not included in the above costs are: dry sheds for storage between periods of sludge use for fertilization, loaders, roads, etc.

Income from sale of dry material.

Upon further drying to about 33% moisture content in piles, the amount heat-dried to 42% moisture is reduced from:

$$11{,}600 \text{ T to } 11{,}600 \cdot \frac{58}{67} = 10{,}000 \text{ T}$$

The net income, after deducting all costs, is about:

$$\underline{\underline{22.50 \text{ DM/T}}}$$

Because of this high income, the economy of this method of artificial drying of sludge can be fully supported. However, when composting refuse and sludge together, this type of processing becomes too costly as in this case the expenses are not compensated for by the income from the compost, or only to a minor degree. In composting refuse-sludge, it is naturally not necessary to dry the sludge to a moisture content of 35% in advance. However, drying only to 60% moisture does not result in any great reduction in total drying costs.

Even if only one selective dryer is installed, the drying will still require a total cost of 2.40 DM/cu m of original material. If the preliminary dewatering of sludge by vacuum filtration is not too expensive for the purpose of combined composting, then other systems described may be selected.

Viersen, July 1961.

Discussions

by O. Andres, President, Soil Improvement Association, Bad Kreuznach.

1. Dr. Sauerlandt concluded his report with a warning against all generalizations in the question of compost evaluation. We could hardly be grateful enough to him for that as it seems to me that now is the time to give such a warning in our field, that of treatment and disposal of community wastes.

Agriculture itself is little adapted to being hemmed in by rules and general formulas. It is even more difficult to set up generally satisfactory rules for the utilization of so complex a material as compost in agriculture. It is fallacious to state such generalities as: compost must in principle be shard-free, or ash-free, or that it is toxic if it contains too much boron or lime. Also, it cannot be stated in principle that compost must be mature before it can be used, etc. Correctly, it may only be said that the above properties may be injurious under certain conditions, while the same properties under different conditions may be favorable to its use.

One cannot also speak of a best or a poorest compost. Similarly, there does not exist an absolutely good or bad composting process from the points of view of soil, crops, climate and agricultural technique planned. All opinions and advice in this field can be applied only to a given specific case if they are to be valid. When a community has to decide whether or not to compost its wastes, it should have an expert make an agronomic analysis of the region first. The study should include the climate, soil, agricultural teçhnique and (soil) structural properties of the anticipated customers for compost, because only when such a fundamental analysis is made is it possible to proceed to other considerations concerning the problem of compost sales. Only then can there be introduced thoughts concerning the most suitable processing method for this particular case. We should, therefore, avoid, especially in the field of waste disposal, all generalizations, preconceived plans, and perfectionisms. We can put our best efforts to no greater ends.

2. Recall, if you will, the graphic description of soil moisture content shown in the paper by Dr. Bause in experiments conducted at Bad Kreuznach. We could see that the moisture content of soil in the plots treated with compost was twice that of untreated plots. Imagine what that means in a dry climate--400-450 mm/yr of rainfall--this doubling of the soil moisture! In viniculture the good years, such as 1953 and 1959, were dry years; that is, water was then a **minimum** and risk was run of too early ripening because of this lack. This increase in moisture of composted plots will certainly be followed, based on experiences with artificial irrigation projects, not only for increased yields but also for improved quality of the grapes. We have also seen photographs showing the improvement in soil permeability by application of compost. Alas, there are many regions where in wet years on heavy soils the plants suffer from chlorosis because the rainwater is not carried off and the roots get insufficient oxygen. Here too our experimental results show that compost can certainly help.

Success in the use of compost to prevent erosion has been obtained in Switzerland and confirmed by our own experiments.

It could also be seen from the graphs that compost application greatly improves the general condition of the soil which is expressed, among other things, by a better oxygen supply to the roots and easier tillability of the soil.

It cannot be stressed too much that the reasons farmers use compost are those for improving soil conditions and not for the sake of supplying plants with nutrients. Every farmer knows that such nutrients are more cheaply and easily applied in the form of special fertilizers. What farmers lack, especially those raising particular crops, are suitable means to improve and regenerate worn out, dead soils. Here is the field where compost acts most effectively and produces the most evident results. The fact that it also contains plant nutrients is a secondary effect enhancing its total value.

Scientists have done much research and learned much about the nutrient value of compost so that we have considerable knowledge of this. Unfortunately, however, too little time has been devoted to the study of biological and physical effects of compost. Here our knowledge is still very sketchy and scarcely any publications exist. It is thus expedient that specialists in soil science, soil physics and soil biology collaborate and begin investigating the effects of compost on the soil.

We have also learned, from the works of Prof. Hilkenbäumer, that many diseases of fruit trees such as collar rot can be made milder or even eliminated by applications of humus and particularly of compost. It seems to me that now is the time to interest phytopathologists in our problems and to induce them to participate in joint studies.

3. It is pleasing that Dr. Sauerlandt in his report discussed the difference between pile composting and surface composting. This concerns a problem that may acquire great significance in the future.

Farmers ought to take an interest in this because in many cases a more valuable product is obtained from processed (raw) refuse than from the compost piles. Pile composting is associated with considerable loss in organic matter as is known. Every composter knows of the shrinkage of the compost heaps. In surface composting all organics can be fully used in the soil. Additionally in surface composting, as Dr. Sauerlandt said, qualitative improvement of the materials results from participation of small animals such as worms in the process.

In his experiments the greatest effect on crop yields were obtained with processed, but not composted, refuse. I believe Dr. Springer obtained analogous results some years ago in Munich. Use of ground refuse in agriculture will probably be possible mostly where there is no cultivation of immature plants such as in vine nurseries, tree nurseries and gardens. Its use is more feasible in mulch form rather than being plowed in as compost.

Continuous use of compost can be made by a skilled organization. This is shown by the example of Mayor Amon of Garching, near Munich, who for 30 years has continuously applied sludge to his land from July to May, or from the first sprout to the last cultivation of potatoes, with the greatest success. The Niersverband also applies sludge continuously throughout the year.

Composting plants, by eliminating composting piles, are saved much space and the cost of turning the windrows. When demand is slack, it can be stored on patches of land, or in part in compost windrows. For small communities, unable to afford a compost plant, a mobile refuse pulverizer and subsequent surface composting is perhaps the only possible way of disposing of the solid wastes.

For all these reasons I welcome the suggestion of Dr. Sauerlandt that surface composting be included in the research program. It is certain that problems of hygiene would have to be accorded special attention in this case.

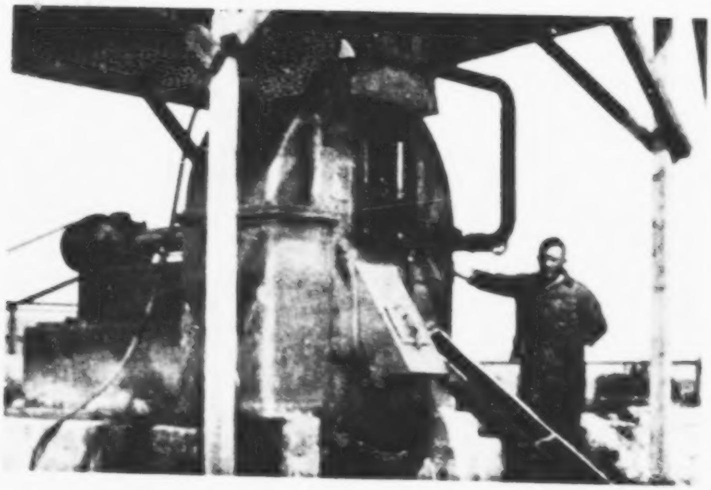


Figure 3. Sludge Centrifuge.

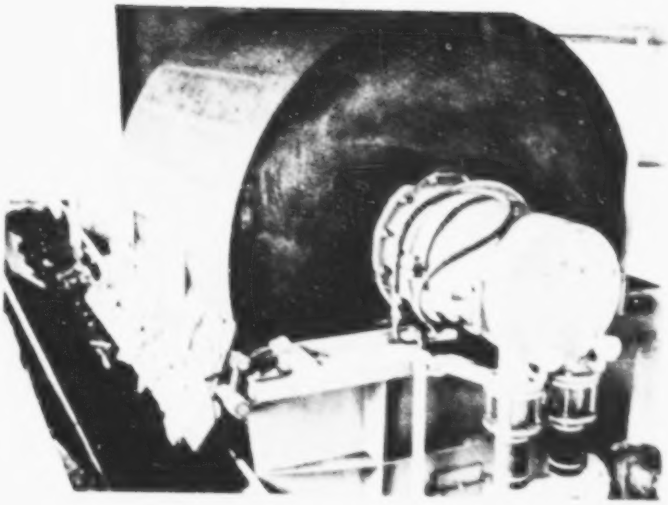


Figure 4. Vacuum Filter.

Reproduced from best available copy.

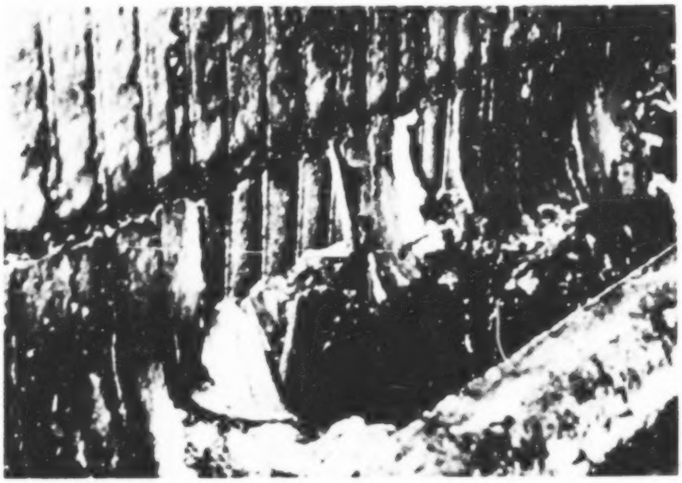


Figure 5. Filter Cake Being Discharged.

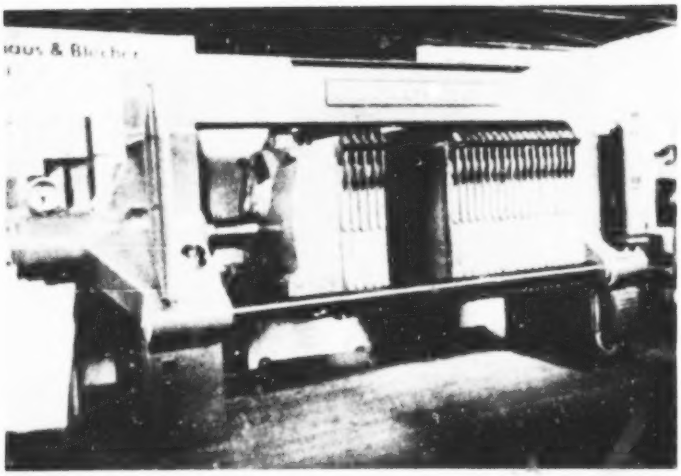

aus & Blecher

Figure 6. Pressure Filter.

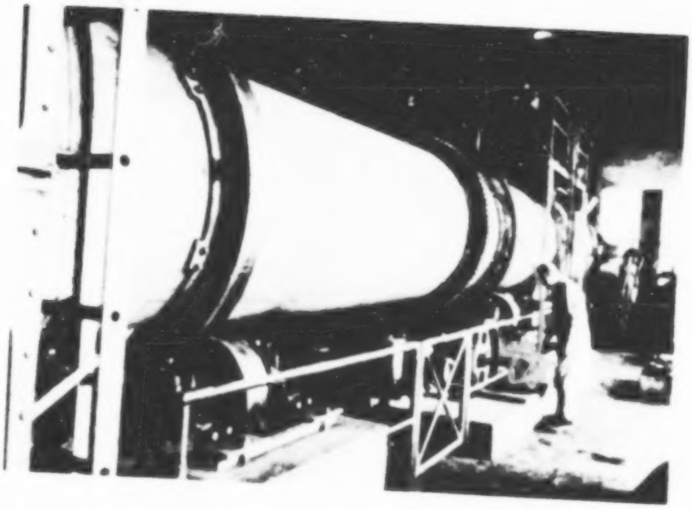
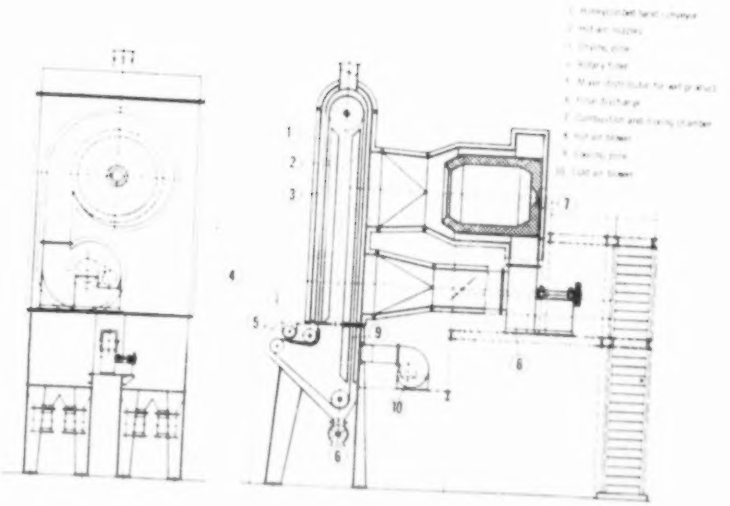


Figure 7. Rotary Drum Dryer.


1 Honeycombed band conveyor
2 Hot air nozzles
3 Drying zone
4 Rotary filter
5 Mixer distributor for wet product
6 Final discharge
7 Combustion and mixing chamber
8 Hot air blower
9 Cooling zone
10 Cold air blower
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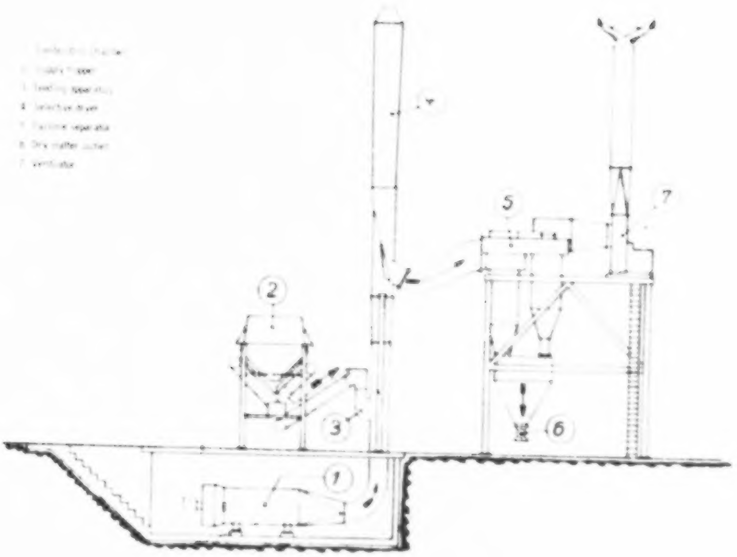
7

Figure 8. Honeycombed Band Dryer.


1. Combustion chamber
2. Supply hopper
3. Feeding apparatus
4. Selective dryer
5. Cyclone separator
6. Dry matter outlet
7. Ventilator
1
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3
4
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Figure 9. Selective Dryer.

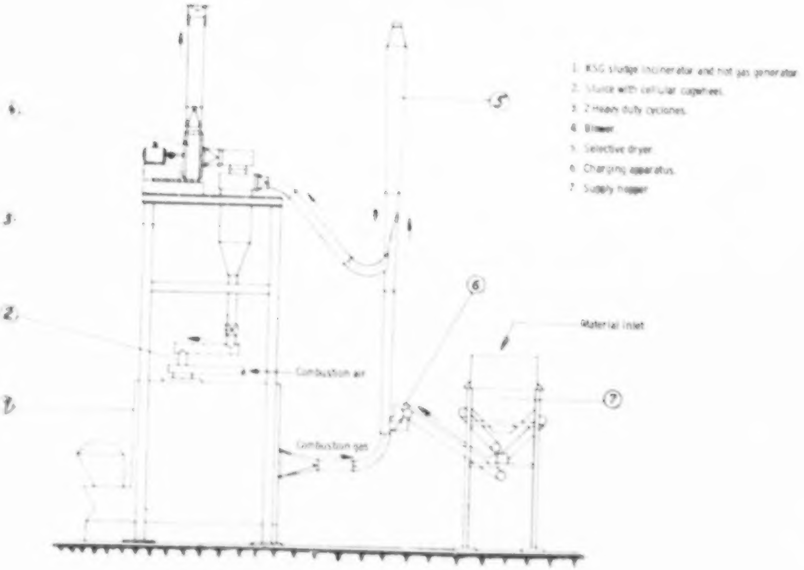
1. KSG sludge incinerator and hot gas generator
2. Sluice with cellular cogwheel
3. 2 Heavy duty cyclones
4. Blower
5. Selective dryer
6. Charging apparatus
7. Supply hopper
4
3
2
1
5
6
7
Material inlet
Combustion air
Combustion gas

Figure 10. Selective Dryer and Sludge Incinerator.

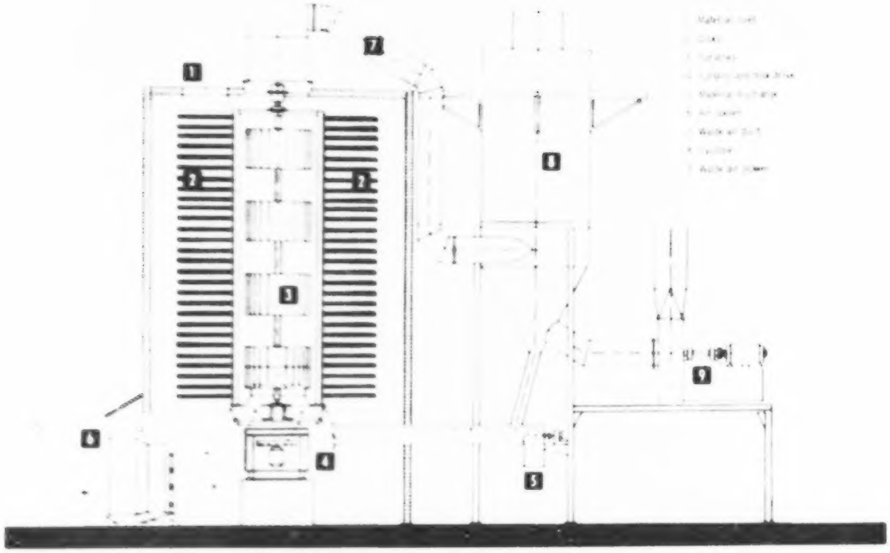
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Figure 11. Stage or Turbine Dryer.

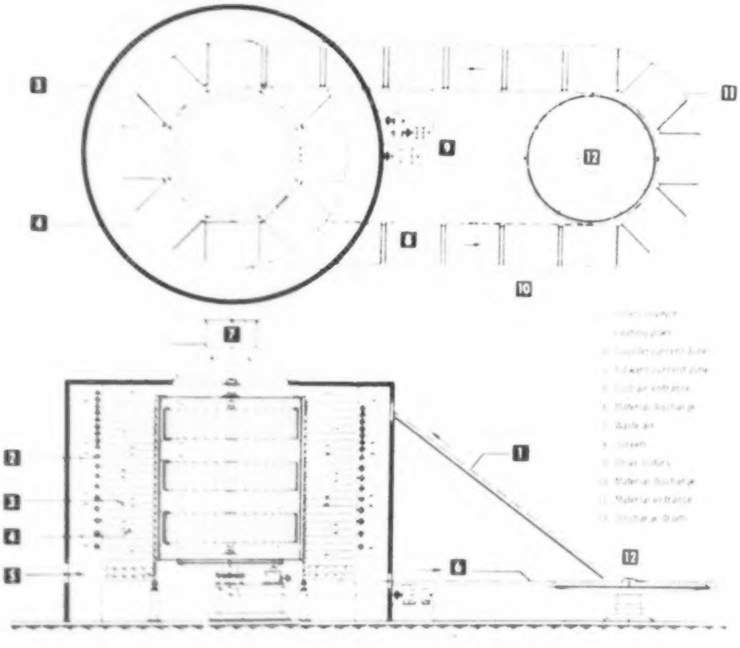
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Figure 12. Turbine Dryer.

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NO. 15

AUGUST 1962

Ferguson, Brooks & Kelly and Warren L. Armstrong, translators
John S. Wiley, editor

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Second International Congress of the International Research Group on Refuse Disposal (IRGR) on Disposal and Utilization of Solid Urban and Industrial Wastes, May 22-25, 1962, at "Haus der Technik," Essen, Germany--Comments by Dr. H. E. Vogel, Secretary, der Schweizerischen Vereinigung für Gewässerschutz (Swiss League for Water Protection), Zürich.

After the second war, the danger of water pollution which was a long-time latent menace began to be widely recognized in many areas. Though the experts first believed they could limit themselves to liquid waste disposal, they soon had to recognize that the problem of disposal of solid urban and industrial wastes was gaining more and more importance. The gravity of the situation, in varying degrees, began simultaneously to be noted in most civilized countries of the world.

Thanks to efforts of various European nations interested in the problem, especially West Germany, the Netherlands, and Switzerland, the International Research Group on Refuse Disposal was founded at an international symposium on refuse problems at der Eidg. Technischen Hochschule in Zürich in July 1955 and Prof.-Dr. O. Jaag, Director, der Eidg. Anstalt für Wasserversorgung, Abwassereinigung und Gewässerschutz (EAWAG) at the Eth, was named President, and Dr. R. Braun of the same institution was named Secretary.

The First International Congress of IRGR at Scheveningen, the Netherlands, April 27-May 1, 1959, had as its aim the establishing of ways and means of investigating the most urgent problems in the field of refuse composting.

At the Second International Congress of IRGR, held May 22-25, 1962, at Essen, with participation of 22 specialists from eight European countries and overseas nations and of 750 others, among whom were over 100 members of Swiss authority and industry representatives, the progress achieved in refuse composting was subjected to critical evaluation; in addition, a thorough study of the results of various systems of refuse burning and incineration was made.

It was clearly shown that discussions are needed today not only on refuse processing per se but also on problems of disposal of inorganics and garden wastes, street sweepings and market wastes, sewage sludge, sludge from neutralization, detoxification and precipitation installations of industry, used oil and residues from mineral oil separators, residues from cleaning oil tanks, and solid and sludge wastes of trades and industries in such ways that requirements of sanitation, public health, aesthetics, protection of waters, and protection of agriculture are satisfied.

The Congress demonstrated in addition that refuse composting and incineration are no longer opposing processes, but they can and should

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profitably supplement each other. All methods of disposal will have to be adapted to the nature of refuse in the future in order to cope with the enormous volume of refuse which already exceeds 700 million tons per year throughout the world.

Systems have been developed to reduce the amount of refuse at its source with home garbage grinders, with a small tin can press, and with kitchen incinerators. The advantage of a considerable saving in costs of refuse removal resulting from these is opposed by significant increases in costs for expanded installation of sewerage and sewage treatment plants or for the installation and operation of incinerators.

The inconveniences of refuse dumps are known to all: their ugliness, stench, vapors, the almost unavoidable danger of fires, and dangers of a hygienic nature. However, controlled dumping of refuse in some cases, according to opinions expressed during the discussions, can still play a useful role in future solution of the refuse disposal problems. The refuse may be deposited in compact layers 1.5 to 2.0 m thick, the mass should be covered with broken glass, pressed tin cans and cartons to prevent penetration by rats, then covered with dirt each time to a thickness of 10 to 30 cm, and impregnated with insecticides as needed to combat flies. The refuse should never be dumped in a place where it might contaminate the ground water. This method should be particularly suitable for coping with a sudden accumulation of refuse, such as in case of an accident or during a peak season.

The ever-increasing rate of construction of sewage treatment plants is accompanied by constantly greater yields of sludge, thus increasing the difficulty of obtaining the necessary drying beds or the possibilities of sludge processing.

Natural drying of sludge is still practiced (e.g. in the region of the Ruhrverbandes) under favorable conditions in order to avoid the relatively costly procedure of artificial drying of sludge. The amount of sludge discharged to drying beds is reduced to about one-tenth of its volume. Another procedure, used by the Niersverband (Netherlands Union), applies sludge like rain upon the cultivated fields. Care must be constantly taken to see that the sludge is as free as possible from injurious components (e.g. poisonous metallic hydroxides) and to have suitable fields available without endangering the health of man or animals. Tank trucks of a capacity of 15-17 cu m are used along roads and field paths to spray the sludge from hoses and nozzles on meadows and pastures after cutting or grazing, with single applications of 25 mm depth or 250 cu m/ha (hectare= 2.5 acres), and on fields before plowing, with an application of 50 to 100 mm or 500-1000 cu m/ha.

Converting domestic, industrial and commercial solid wastes, as well as sewage sludge, to compost should be considered as one of the primary methods of waste disposal as expressed at the Congress. As such compost can be considered hygienically satisfactory, odorless, and incapable of breeding any kind of vermin, and as its volume is much reduced from that of the raw wastes, it may be readily stored.

There is a continually greater tendency in agriculture to provide the soil with humus in addition to mineral nutrients for crops. European and American scientists are conducting experiments in this area. Various wastes are being studied regarding their biological decomposition including: the chemical structures of the organic compounds and their breakdown by enzymes, physical conditions for such breakdown, and factors influencing microbial activity, such as moisture content, nutrient content, trace elements, pH value, and toxic ingredients. In the EAWAG alone, methods of chemical analysis have recently been developed and various techniques established for performing composting experiments. Analogous studies have been made in Germany, the Netherlands, Italy, and other nations.

Research institutes of national members of IRGR have long conducted studies on the utilization of refuse and refuse-sludge composts in horticulture, viniculture and forestry. In comparison with other humus materials, these have been tested as to their influence on various soils, (crop) yields and quality, and toxic or injurious effects.

Experiments in apple orchards showed that the application of 100 (metric) tons/ha on sandy and clay soils produced increases in yield of 13 to 76 kg/tree as compared to those receiving only mineral fertilizer application. There was also considerable increase in new growth and trees provided with optimum amounts of compost and peat showed better stand of leaves and less premature fall of leaves during dry periods than untreated trees.

In viniculture, refuse and refuse-sludge composts can replace formerly available agricultural materials insofar as they are high in organic matter, sanitary, and free from toxicants. Such composts are valuable in viniculture, not so much for their nutrient content or their effect on nutrients as for their improvement in physical conditions of the soil. These composts can effectively prevent erosion damage to vineyards on hillsides, ease the tilling of heavy soils, generally improve the soil structure, and provide material improvement in soil moisture conditions.

In forestry, compost is used on heavy soils or worked into the upper soil layer to loosen its structure, promote drainage and aeration, increase capacity for the exchange of nutrients, and make the soil warmer. In loose or excessively permeable soils, compost enriches the soil and increases its water retention capacity. Compost likewise serves well in arboretums or tree nurseries, where soils rapidly become exhausted because of continual planting of young trees and removal of nutrients from the upper soil layers, and also in reforestation programs. However, it should be noted that only well stabilized composts that are free of shards and pieces of metal and that are satisfactory hygienically can be used continually in forestry.

Finally, compost is successfully used for restoration of mine areas. In the subterranean lignite mines of the Rhine region of West Germany, it is estimated that the demand for arable lands will reach 25,000 ha by the year 2000 and that therefore about 300 ha/year should be treated for recultivation. Thus, at 300 to 600 tons of compost per hectare, corresponding to the annual yield of raw refuse of 1200-1500 people, this area could make use of the refuse from a population of about 450,000 people.

Refuse incineration has been practiced for a long time. Its main advantage is in the destruction of refuse in a sanitary manner, the killing of pathogenic microorganisms, and the considerable decrease in refuse volume. But incineration is complicated by the heterogeneous composition of refuse and the seasonal variations in quantity as determined by the geographic location of the community and the living habits and economic level of its inhabitants. Often the installation and operation of an incinerator requires rather high costs, from 25 to 37 Swiss francs per person. If 1000-1200 tons/day of refuse are available for incineration, corresponding to a population of at least 1,250,000, the plant can also be used for production of electricity or steam.

As particularly noted during the Congress, incineration can be combined with composting and the salvable material may be sorted out beforehand.

Recently, in response to widespread need, small incinerator plant plans and construction have been promoted. These may be used in communities of 1,000 to 100,000 population for treatment of domestic, commercial, industrial and other bulky refuse and as a supplement to installations for biological treatment. They can also be used in large industries for burning waste products, solid residues, and similar materials. In addition, there are small incinerators available for homes, businesses, and hotels.

To make small incinerators practical economically, their operation should usually be extended to include the burning of sludge, oil residues, and gasoline refinery wastes. However, incinerators of this kind are still in the experimental stage in which attempts are made to use the waste heat from combustion of solid wastes to dry sludge-like wastes.

Refuse incineration is accompanied by grave problems in the field of air pollution. Attempts are being made to eliminate air pollution by the installation of electrostatic filters to trap dust particles and by high combustion temperatures to destroy unpleasant odors.

As stated in one Congress paper, refuse disposal plants should be carefully planned, including the following aspects:

1. Regional planning and delimitation of the area to be served in order that construction will be as economical and technically feasible as possible, and including combined collection of the refuse from several communities, with the collective purchase and operation of modern efficient refuse trucks where possible;

2. Estimation of the quantity and nature of the refuse and interpretation of the results of these preliminary investigations;

3. Choice of method of disposal; the increasing amounts of refuse (expected to increase more in volume) to be handled gives more and more advantages to the installation of a combined system of incineration and composting;

4. Site selection for the future refuse disposal plant which should not be in the geographical center of a given region but instead at a location most favorable from the points of view of economy and transport.

Finally, President O. Jaag stated that the aims of the Congress had been very satisfactorily met; that is, the intensifying of international cooperation in all phases of refuse disposal, of future research projects, and coordination of planning.

Note from the Secretary: Papers delivered at the Second International Congress of IRGR in Essen can be individually obtained in German, French, English, and Italian (see Reprints from the Secretariat at the end of this issue).

1. Agriculture and Compost by Agriculture Engineer O. Andres, Bad Kreuznach, presented at Second International Congress of IRGR, Essen, 1962.

It seemed important to me to learn the views of (farmers) agriculture concerning the use and value of compost and problems relating thereto because they are the chief consumers. Agriculture, as used in this discussion, includes all branches of agriculture: farming, forestry, viniculture, horticulture, orchardry, market gardening, and other special forms of cultivation as practiced. Compost here means exclusively compost of refuse or of refuse and sludge.

A principal concern of agriculture today is the maintenance of a good condition of the soil which, despite abundant applications of nutrients, is losing its fertility to an increasing extent, becoming sterile, and becoming more and more difficult to till. Symptoms of soil regression are: loss of crumbly state, destruction of structure with resultant packing and loss of water-holding capacity on one hand, and increasing stagnation and deficient aeration on the other. Dr. Leenheer (1) has shown that poor structural conditions alone can cause yield reductions up to 22 percent. Moreover, cultivated crops are continually more heavily attacked by diseases and pests, despite the increasing use of pest control measures. For various reasons soils used for special crops are the ones most severely endangered. Eye-catching erosion damage is readily perceptible to the layman.

Scientific research confirms the findings made in practice and essentially traces the phenomenon to lack of humus. Natural sources of humus, the wastes from the crops, in general are insufficient for the maintenance of good soil conditions. Supplementation by use of green manures is generally not possible and stable manure, becoming more and more scarce, will be confined in the future to the smallest and specialized operations. There is thus a considerable lack of humus which will have to be remedied.

Composts, therefore, have a real chance of finding a market in agriculture inasmuch as their analytical values are on the whole comparable to those of stable manures and their action on the soil in most cases surpasses that of stable manure in the opinion of farmers. Unfortunately, we have neglected the physical and biological problems of the soil for a century in favor of problems of agricultural chemistry and, specifically, plant nutrition. It is obvious that such biased methods of consideration and treatment of such complex processes as those that come into play in crop cultivation will one day prove inadequate.

While there has been a little more activity in the fields of soil physics and biology in the last 10 years, our knowledge in these areas is still very deficient and much will have to be done to complete it. Farmers should take every opportunity to demonstrate to competent authorities the fact that it is high time to shift present emphasis in soil research from chemical to biological and physical aspects. Whereas the present epoch relates to plant nutrition per se, the coming epoch should be addressed to soil conservation.

Publications reflect the fact that agricultural research is too much preoccupied with chemical problems at the expense of physiological and biological problems. Literature on plant nutrition predominates overwhelmingly, while very few publications are concerned with the physical action and evaluation of compost and scarecely any at all with biological action and its evaluation. This necessarily leads to false considerations and to a biased evaluation and underestimation of the virtues of compost.

It bears repeating that, just as agriculture does not expect direct fertilizing action from the use of green fertilizers, stable manures or bedding straw, it should not expect such action from compost. Farmers know well that nutrient substances may be applied as needed individually and more cheaply in the form of commercial fertilizers. Agriculture uses green manures, stable manure and bedding straw, as well as compost, exclusively for reasons of soil improvement. For them, the direct or indirect nutrient effects are a secondary, not a primary, consideration. Therefore, in practice, composts are a means for soil improvement and not (for supplying) nutrient fertilizers.

Soil improvement and, particularly, restoration of soil impoverished by overcultivation, is a very complex task. It cannot be solved in a short time. We know from research projects how difficult and tedious it is to raise the level of humus in a soil. It is thus too much to expect that a compost will be able to increase crop yields in a single year. Lasting improvement is generally to be expected only after several years of its use. It will be shown less in abrupt yield increases than in a balancing out of yields and in a greater stability of the soil in the face of extremes of weather conditions.

While comparative studies of NPK fertilizers and composts may have significant value in research, such comparisons can result in false interpretations and erroneous conclusions concerning compost. It has happened on the basis of such results that compost is reported to have scarcely any value for farming because its yield increases remain below those of NPK fertilizers. One can certainly not compare soil-improvement means with nutrient fertilizers. I know of no trials comparing peat or Flotal or Krilium with nutrient fertilizers in parallel and then of calculating from the resultant yields of such experiments the value of them as means of soil improvement.

Because we know that the humus content of soil exerts a dominant influence on soil fertility, the humus content of compost represents the chief interest for agriculture. This is designated in analyses by investigational institutes as "active organic matter" and it should constitute a criterion of first rank in agriculture.

According to Scheffer (2), the organic mass is composed of easily decomposable nutrient humus and of stable humus that is difficult to decompose. The nutrient humus serves as a food source for soil microorganisms and therefore acts essentially on the biological phase of the soil. On the other hand, the stable humus influences the chemical and physical properties of the soil. Springer (3) points out in this regard that the problem of whether to use fresh or decomposed compost depends upon soil conditions. Emphasis should be placed, according to individual agricultural needs, upon either a high content of nutrient humus or of the stable humus of a compost.

The content of nutrient humus declines as composting progresses; that is, the fresher the compost material the more nutrient humus it contains. The content in nutrient humus of a compost after complete decomposition is essentially zero, and humus is then present only as stable humus. The material therefore loses a considerable quantity of active organic matter during composting. This means that, in many types of agriculture, compost value declines as rotting progresses. Most researchers, comparing fresh compost with well-rotted material, consistently have shown the better action of the fresh material--Gerretsen (4), Kortleven (5), Raub (6), Sauerlandt (7), Springer (8), and others. Agriculture is therefore greatly interested in expeditious handling of organic matter during composting and also is taking advantage of the better effects of fresh compost. The ideal solution would be the surface composting recommended by Sauerlandt (7) in Stuttgart. Composting in this way most nearly corresponds to natural rotting in the forests or on the steppes. Losses in organic matter and nutrient materials are held to a minimum and the many intermediate products of rotting--auxins, hormones, antibiotics--are able to act on the soil, on its microorganisms, and on its crops. Humification is ideally adapted to local conditions by participation of soil microorganisms and worms.

The possibilities for sheet composting should be investigated as soon as possible. Both community authorities and agriculture have considerable interest in this. It represents savings of space and of labor. Surface composting may be the only economically feasible method of refuse disposal for small communities. Of course, hygienic requirements must be considered but I am optimistic about this. An active soil possesses great ability regarding self-purification. There are numerous records of 30 years or more of continuous application of sludge or even of sewage without any damage to health up to now.

Agriculture will resort more and more in the future to mulching because it is being recognized how injurious it is to leave the soil exposed to weathering too long. We know about ground covers after Sekera, about mulches, straw coverings, and also about compost. The bridge between surface composting and soil covering would be easy to cross.

"Ripe" or mature compost means not only the fulfillment of a biological process but something more, in that there is a time value. One might think that an unripe compost is less valuable than a ripe com-

compost. I therefore propose to abandon the term "ripe" in favor of completed rotting, the term degree of ripeness in favor of degree of rotting, and the term ripeness test in favor of rotting test. These terms seem to be clearer and less subject to misinterpretation.

It has been stated that by applications of compost or fresh material we can supply nutrients to the microorganisms of the soil. Unfortunately, we still lack scientific reports on just how these composts act on the life of the soil. This concerns phytopathology which presents important questions in agriculture.

Many examples have shown that crop damage by insects and plant diseases is much less in healthy soils than in worked-out, dead soils. Antagonists of plant diseases and parasites are mostly absent in the latter. Schupp (9) showed that fewer attacks of root nematodes on cucumbers and tomatoes and of brown rot on cucumbers occurred after application of compost. Hilkenbaumer (10) reported that attacks of "gummy wood" virus and of mottling of apples subsided with certain content of humus in the soil. Cossack (9) stated that applications of old compost controlled attacks of needle blight in scotch pine forests. Merker (9) showed reduction in gall moth attacks in scotch pine shoots by similar applications.

I am convinced that compost can contribute greatly in combating still other plant diseases and in maintaining good healthy plants. Recently, the Research Committee of Giessen University successfully worked out many problems of the microbiology and hygiene of humans, animals, and plants with reference to windrow composting in the interests of public health. It is now urgent that studies be made to the same extent on the biology of the soil and the hygiene of the crops.

To improve his soil one must first give it good structure. While recent studies have been concerned with the effects of compost on soil structure, there are many gaps to be closed in our knowledge. First studies were understandably with prevention of soil erosion. Peyer (11) and Eggenberger (12) of Switzerland and Banse (13) of Germany, as well as Homrighausen, have reported positive findings in this field. Regarding regulation and supply of moisture, results are available from Banse (13) and Eggenberger (12) with regard to pore volumes. These works confirm the positive action of compost utilization.

We know nothing concrete about the problem of formation of black earth and stabilization of soil friability with compost use. We know little about improvement of soil aeration or of the effects of compost on chlorosis. I believe that nothing has yet been done in the field of soil temperature effects with compost use. Our knowledge generally in the important fields of improvement of soil structure and soil physics is very sketchy. We request the soil chemists to study improvement of the absorption properties of soil and the formation of black soil with compost application.

While I am opposed to judging compost value by the criterion of nutrient content, this does not mean that agriculturists should not take advantage of the nutrients it does contain. They naturally make the compost more valuable, widen its field of action, and reduce the cost of its use as a means of soil improvement.

Concerning macronutrients, the high CaO content at first causes fear of the danger of too much lime. But, recently, it has been shown that the alkaline substances in compost have less effect than do those in ordinary lime-containing fertilizers. If compost is reasonably applied, such damage may be avoided because applications of acid fertilizers or peat, available at pH values of 4 or less, offers a balance. Research scientists should study this alkaline effect of compost and means of its correction. (Editor's note: Highly alkaline refuse or compost in the United States is rare because our cities do not burn as much coal or other solid fuels as they do in Europe and there is therefore less alkali ash in the municipal refuse.)

Regarding trace elements, I believe we will experience some disappointments because we are still underestimating the extent of microerosion in our soils and their impoverishment in elements of all kinds. We foolishly believed for hundreds of years that good crops could be produced with sufficient applications of N, P and K, only to discover that one deficiency symptom after another appeared, leading to discovery of more and more (needed) trace elements. The time will come when our fertilizer sacks must contain nearly all the chemical elements if our soil is to be kept in order and our crops are able to find in it that which they require for healthy growth, harvest development, and attainment of maturity.

As most of the elements are present in compost, we can only do our soils and crops good if we do not use compost in excess. Fortunately, it has been shown that damage from boron need not be expected upon reasonable application of compost.(14)

I believe the effect of compost on soil texture has been underestimated. Sappok (15) showed the following average values for compost: clay components - 4 to 5 percent; silt - 9 to 11 percent; particles larger than coarse sand - 25 to 30 percent. As we apply 100 (metric) tons/ha every 3 years in orchardry and viniculture, this means we are adding appreciable amounts of soil and silt to the soil in addition to coarse particles. I doubt that this remains without effect on the soil.

It is a mistake to require that compost be free of coarse particles and of ashes. We have many heavy soils, lacking the necessary soil structure, and we know that much structural damage is due to packing (caking or crusting) of the soil. Such soils can be helped, insofar as the crop permits, by adding coarse materials in compost. It would thus be wrong to remove all coarse particles from compost, be they glass, stones or plastics.

Alternatively, we have soils in which the addition of a binder is beneficial, such as sandy or gravelly soils. It would be damaging to sieve out the fine components and, in any case, the compost would lose some valuable soil-improving effects. Fine components do not consist solely of dangerous ashes but also of very desirable substances such as clay and humus. In Vienna, only composts with particles smaller than 36 mm diameter are used. This compost is of excellent quality.

It still remains to be learned whether or not screening removes those substances in addition to ashes that, according to Sauerlandt (16) and Trenel (17), are specifically involved in the formation of humus. I can only give the key words: clay, humus, lime, iron, and flocculation and coagulation. From what does the action of old compost on soil structure originate? Humus and nutrients are eliminated. We would like scientists to take up this wide field of research.

A word about the evaluation of need for special quality composts in agriculture: --Enriching compost with nutrients makes little sense in agriculture. It increases the price of compost and the same effect can be achieved more cheaply and more according to individual needs by using commercial fertilizers. Adding peat to compost is only recommended when both sources are close together. It is generally more advantageous and cheaper to alternate applications of peat and compost in a fixed cycle.

Addition of microbial mixtures, particularly of unknown composition, to compost is of no interest in agriculture and makes the product more costly. Each locality has its own flora and fauna which cannot be permanently influenced by several hundred kg/ha of costly compost. When it is realized that an active soil contains twice the weight of animals living on its surface in the microbial life of the soil, it should be clear that we cannot exert much influence on this teeming population with doses of several tons of enriched compost. There would be required much more substantial quantities, on the order of 30 to 50 tons/ha/year, and therefore it would have to be made much cheaper.

Similarly, if we wish to prevent erosion, we will not succeed with small amounts.

Thus, in agriculture, there are certain limits to the amount of compost to be applied in order to achieve success. But everything that increases compost cost endangers its chances of being used in adequate amounts and is detrimental to its sale. Quality and special composts may have certain interest for amateurs in cities, but the professional farmer does not generally need them. It would be a mistake to believe that the problem of sale of compost as a whole can be solved by making and selling such composts.

Taking agriculture as a whole, it is evident that only a minimum price will be tolerable for the compost. In the Netherlands, for example, agricultural compost still sells for 3 to 4 florins ($.75 to $1) (per ton)and nearly half of that produced is sold to farmers at this price. Only in special fields are higher prices paid. (Editor's note: In 1959, the editor was told in the Netherlands that the average price for compost was $2.53/metric ton.)

To consolidate and expand compost sales, we should plan to reduce the price of compost and keep it low, and not make it more expensive by additional processing.

Adding compost to soil produces a multiplicity of effects upon soil and crops. We are adding an organic substance that has a wide range of physical, biological and chemical effects. We thus make available to crops certain amounts of primary nutrients and of the entire range of trace elements. Compost also contributes lime to soil and influences the granule size of the loam. We introduce substances to the soil which somehow alter the friability over the decades. Finally, we contribute to the control of parasites and plant diseases.

The outcome of all the possible actions, however, depends largely on local conditions of compost use; that is, on the soil, climate, terrain, and type of crop planted. What is proper and useful in one locality may be wrong and harmful in others. It is quite difficult to set up hard and fast rules for agriculture which is concerned with a multiplicity of living processes. How much more difficult is it to regulate the uses in agriculture of such a complex substance as compost? While for the technician 2 x 4 = 8, for the farmer it may be the result of a number of individual calculations with many unknown quantities.

The study of all questions relating to compost use should be limited to those qualified specialists in agriculture that are familiar with compost. They may make evaluations, quality checks, and sales analyses. As Sauerlandt (7) stated, we must emphasize prudence about drawing conclusions concerning compost if errors in judgment, calculation and development are to be avoided. No compost can be said to be the best. It is wrong to require that all composts be completely rotted. Nor is it right to require composts to be free of ashes or coarse particles. We must therefore avoid glibly preparing general conclusions, rules, and refinements. Considerable progress can be made in the use and sale of compost by honestly studying the problems of production, evaluation, and utilization. We should also remember that one practical example is generally of much more value than too much skepticism and too many complicated theoretical considerations.

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2. The Refuse Composting Plant at Stuttgart-Möhringen, by Superintendent Glockner, Stuttgart.

After a long trial period, the City of Stuttgart's refuse composting plant began operating on October 2, 1961. The plant installation was part of an over-all plan to solve the refuse disposal problems of this city of 650,000 by means of both composting and incineration. Most of the wastes, particularly those from industrial areas, can be disposed of only by incineration but, because of the vast urban area surrounding Stuttgart, composting is practical in some of the fringe areas.

The suburban area south of Stuttgart, about 150-200 meters above the Stuttgart basin, is occupied by residential districts and by agricultural and market-gardening activities. Therefore, it seemed appropriate to construct a 1,434,000 DM composting plant as a large-scale experiment to serve about 80,000-100,000 population.

In making their decision, city officials assumed that not necessarily all of the product would be used by agriculture, but that sanitary requirements, the need to treat the refuse to render it non-hazardous, and to render it suitable for opening filling had to be emphasized. Numerous conferences with gardening and agricultural groups and visits for consultation to the compost plants at Baden-Baden, Heidelberg, Kreuznach, and Uzwil, including the large wine growers organization at Untertürkheim, indicated that, once the compost is available, it will find an interested market.

The plant operates under the Dorr-Oliver (rasping system with windrow composting) system having: a 120-cu m refuse bunker, the usual magnetic separators for cans and scrap iron, hand separation of noncompostable materials, and a D-O rasping machine and ballistic separator for the inert materials. The entire plant is in one building and at present has available a 4,000-sq m composting field. An important difference from other plants consists of an incinerator with a special grate built by the Esslingen Machine Works which is said to provide greater capacity than the ordinary vertical furnace. The 1- to 1½-ton/hr furnace permits burning of large quantities of industrial wastes and does away with the tedious sorting of material on the conveyor belt from the grinder. The Stuttgart works is a combination plant suited to the needs of a middle-sized city where it is impossible to solve the total refuse problem by composting alone.

Final judgment about operation of the composting plant must await a long period of operation. However, results so far at Stuttgart have been entirely satisfactory, although in a plant of this sort some technical improvements must be made in both composting and incineration operations. It is also too early to predict quantities of refuse treated or of compost produced because the incinerator here creates special conditions.

Extensive advertising for compost sale has been intentionally avoided because the appropriate compost preparation must be determined to meet the local needs and it is not desired to arouse hopes by premature propaganda. The first compost produced was therefore used almost entirely for covering a dump to convert it to a sanitary landfill. Meanwhile, however, a demand had developed such that in October 1961, 680 tons and in December 629 tons were sold at 6 DM ($1.50) per (metric) ton, including loading. The low price was set with the concept that the primary objective of composting is the sanitary treatment of refuse.

Sale results are now very satisfactory, but we are aware that increased production will cause increased difficulties in sales and that small plant experiences cannot be transposed to large plants. The market area of a large plant is not much different than of a small one with regard to hauling costs and thus the possibility of incineration assumes particular importance. A combination plant such as this one may enhance fulfillment of the composting concept by elimination of difficulties too often encountered in planning a composting plant alone. The City of Stuttgart believes it has made a contribution to the composting concept in its new plant. An adequate review of costs and yields in both operations will be reported as soon as operation has been continued long enough.

3. Refuse Analyses, by Dr. R. J. Häfeli, Zürich. (from: Mitteilungen der Vereinigung der Grosskesselbesitzer (Essen), No. 74, October 1961).

The methods of refuse analyses described below frequently serve as a prerequisite to the construction of large incinerators. Analyses of refuse for incineration plants are most difficult because the refuse may contain any and all substances having any connection at all to mankind. Additionally, the composition of refuse varies seasonally.

To determine the composition of refuse, large samples are dried, ground and separated into their constituent parts. The following combustible substances are contained in refuse:

fruit pits
eggshells
potatoes
bones
bread
vegetables
seeds
leaves
down
yard wastes
cheese parings
reeds
meat
excelsior
hay
matches
straw
cork
brush
wood
bottle caps
rags
string
textiles
linoleum
Celluloid
cellophane
polyethylene
other plastics
feathers
hair
mattresses
pelts
leather
rubber
paper
ashes
slag containing carbon
coal wastes

In addition, the following non-combustibles are found: glass, porcelain, ceramics, construction wastes, tin cans, tools, toys, etc. The combustion heat of refuse is determined from its content of these various substances.

Such an analysis is tedious and expensive. The accuracy of the determination of heating value of refuse is dependent on satisfactory determination of the combustion heat of its components, but only for the sample as taken. To avoid many difficulties, a simplified procedure for analysis has been devised and tested. It may be carried out in a relatively short time and it is simple and yields reproducable values.

Sample-taking:
Refuse differs from city to city and from one part of the city to another. To obtain adequate representation, it is recommended that three districts or streets be chosen that show typical characteristics; such as, a new part of the city with central heating and with gas or electric cooking and water heating facilities; an older part of the city with heating by individual stoves or open fireplaces; and another part where the heating forms are mixed. When seasonal samples are taken, they should always be taken at the same place so that composition variances of the refuse may be comparable. With widely differing sites, random samples can serve for comparison and control. Samples should be carefully taken to correspond to the average for the locality concerned. This is best done by emptying every other refuse can into a truck until about 500 to 1000 kg of refuse has been collected.

Fractioning:
The refuse, conveyed to a selected site, is immediately weighed and carefully sifted through a 25 mm sieve. All inert material is immediately picked out and weighed -- stones, pottery, glass, ceramics and metals, designated as "i". Coarse combustible components retained by the sieve are also weighed and designated "gr". Material passing through the 25 mm sieve is sifted in a 5 mm sieve and the residues are designated as "mf" (medium-fine) and "f" (fine). Refuse loses a little weight during sorting and screening due to partial drying and the loss by evaporation has to be taken into account: That is;

$$G = gr + mf + f + i + X$$

where G = total refuse weight before sieving,
gr = coarse combustibles weighed as a fraction,
mf = medium-fine combustible components,
f = fine combustibles,
i = inert (noncombustible) components,
X = loss from evaporation (and perhaps as dust) but calculated only as water, and

$$X = G - (gr + mf + f + i).$$

If the sum of the various fractions is "S", then:

$$X = G - S$$

Generally, however, the loss from evaporation during fractionation can be disregarded; it does not exceed 2 percent based on experience.

The proportions of the various fractions are:

$$gr = \frac{100\ gr}{S}\ \% \qquad mf = \frac{100\ mf}{S}\ \%$$

$$f = \frac{100\ f}{S}\ \% \qquad i = \frac{100\ i}{S}\ \%$$

The sum of these fractions is 100 percent.

If it is desired to calculate the value of the proportions to the original weight of the sample, then the loss in water, X, is to be added proportionately to the individual fractions. Values thus obtained are to be adjusted so that their sum amounts to 100 percent. It is uncertain whether or not proportional distribution is correct inasmuch as the loss in moisture of individual bodies of refuse varies. For example, the coarse fraction can show 50 percent moisture content, the fine only 15 percent. This shows how difficult it is to make an evaluation.

When fractionation is carried out rapidly, X is very small and can be neglected as done in the formulae for individual proportions. For combustible materials from large samples, the following key may be used:

Weight Initial Fraction	Weight of Sample to be Analyzed
0-10 kg	entire sample
10-50 kg	about 10 kg
50-100 kg	about 20 kg
over 100 kg	2 samples, 20 kg each

Sampling the coarser combustible materials requires special care in order to represent a good average. Samples should immediately be weighed in tightly closed impermeable containers.

Approximate Moisture Content of Samples:

Individual samples are dried in an oven at 103-105° C for 24-36 hours. The loss in weight is expressed in percentage and corresponds to the moisture content.

Initial weight = a; Weight after drying = b

Approx. moisture content = $Fg = \frac{100(a-b)}{a}\ \%$

Sample Preparation for Determining Heat Value, Ash Content, Content of Combustibles, and Residual Moisture:

Dried samples are individually pulverized in a grinder, paying attention to exclude all metals from the fractions. The grinding mill can pulverize all substances, including rubber and gum. Medium-fine and fine fractions may also be ground with good results. Individual samples are well mixed and a sample of each of about 1 kg is taken. For determination of various chemical constituents, samples are reground in a fine grinder. This includes determination of calorific value.

Just as moisture may be lost in the screening and sorting, moisture may be picked up by the dried samples. While this is small but detectable, the milling processes should be performed in a dry room as rapidly as possible.

Determination of Residual or Hygroscopic Moisture:

One or 2 gm of previously dried (and ground) sample is redried at 105° C for about 2-3 hours to constant weight. The residual moisture content is:

$$Fr = \frac{100(a_1 - b_1)}{a_1} \%$$

where: a_1 = initial wt. of previously dried sample,
b_1 = weight of redried sample, and
Fr = residual moisture content.

Total Moisture Content of the Refuse:

The total moisture content (Ft) is calculated from the approx. moisture content (Fg) and the residual moisture content (Fr) as follows:

$$Ft = Fg + Fr \frac{100 - Fg}{100} \%$$

Determination of Ash (Theoretical Content):

One or 2 gm of redried sample are completely ashed in a platinum dish at 700-800° C, raising the temperature gradually to that heat. Care is used to insure that no particles of ash fly away during incineration. Burning is complete when no particles of carbon remain in the dish.

(example analysis on next page)

Example of Analysis

Sieve Analysis

	Coarse %	Medium %	Fine %	Inert %	Total %
Total Fraction	73.0	5.5	12.5	9.0	100.0
Moisture	33.4	30.8	22.5	0	
Ash	26.0	40.4	48.7	100	
Combustibles	40.6	28.8	28.8	0	
Volatile Matter	33.2	21.6	20.0	0	
Fixed Carbon	7.4	7.2	8.8	0	
Calorific Value, kcal/kg	1660	1126	1250	0	

Calculations

	Fraction	Moisture Content, %		Combustible Matter, %		Ash, %		Calorific Value,Kcal/kg	
Particle Size, mm	%	In Fraction	In Raw Refuse	In Fraction	In Raw Refuse	In Fraction	In Raw Refuse	In Fraction	In Raw Refuse
0 - 5	12.5	22.5	2.81	28.8	3.6	48.7	6.1	1250	156.4
5 -25	5.5	30.8	1.70	28.8	1.59	40.4	2.23	1126	62.0
Coarse	73.0	33.4	24.4	40.6	29.6	26.0	19.0	1660	1211
Inerts	9.0	0	0	0	0	100	9.0	0	0
Total	100.0		28.9		34.8		36.3		1430

4. Erosion Damage in Viniculture and Preventive Measures, by Dipl. Agric. Engr. E. Peyer, Eidg. Versuchsanstalt für Obst-, Weinund Gartenbau (Institute for Orchardry, Viniculture and Gardening), Wändenswil.

Introduction

Erosion occurs naturally in vineyards and can cause heavy losses. While grape growers have fought erosion for centuries, they must now increase preventive measures, as will be explained below. No other form of agriculture is so exposed to the dangers of erosion for the following reasons:

In local viniculture, the soil remains bare all year and it is unusually severly exposed to weathering effects. There is no protective covering of vegetation to reduce erosion by rains. Our vineyards are located on more or less steep slopes where erosion can be particularly dangerous. The fields are often terraced with no cover provided for the terraces so that rainwaters descend from one to the other in torrents.

Vine growing has been practiced as a single crop on the same soil for centuries. The intensive care required by vines, which must be cultivated about 20 times per year, makes heavy demands on the unprotected soil. Particularly unpropitious is the effect of spraying, for example, which must be done when the soil is wet. The single-cropping tends to make the soil humus-starved, again strongly increasing the danger of erosion.

Earlier, less was written and spoken regarding vineyard erosion than now, but the operating methods in grape-growing are different today. Vines were formerly planted relatively close together, about 12,000 to 14,000 vines per hectare with a minimum of 10,000 and not in straight rows. Also grape arbors, with their long wooden beam supports, reduced the erosion somewhat. These thick stands of vines suffered less water erosion than modern fields with only 5,000 to 8,000 vines per hectare and spaces of 1.2-1.8 m between the rows.

Another factor affecting erosion damage is the method of fertilizing the vines. This naturally varies from one grower to another and from area to area but, generally, we believe that the use of mineral fertilizers has greatly increased and the use of organics, such as stable manure and composts, has considerably declined. One reason lies in the greatly increased yields per unit area by the new methods. But the increased use of plant food from the soil cannot be compensated for by the use of commercial fertilizers. Moreover, stable manure is becoming increasingly rare and expensive for use in vineyards simply because of the cost of hauling and distribution on the land.

With the decrease in humus fertilizers on the land there has been an unfortunate sharp increase in erosion damage. It is well known that soils, having lost their friable structure and being inadequately supplied with humus, are very prone to erosion damage. This is all the more true with unprotected vineyard soils on exposed slopes. We therefore assert that the fight against erosion in vineyards consists largely of supplying enough humus to the soil.

Importance of Erosion in Vineyards

We need not define erosion here except to emphasize, in addition to surface erosion which may form gullies up to 1 m in depth, the loss in nutrients. These are irredeemably carried away by the runoff, whereas the eroded soil can be partially brought back. We have more or less accurate figures on the extent of erosion in storms: We have measured erosion on a steeply sloping vineyard at Eglisau since 1958. The eroded soil was trapped in cement basins and carefully weighed. In three storms totalling 100 mm of precipitation, 3,953 kg of fine soil or 110 tons per hectare was washed away from the untreated plots, about 58 cu m of damp earth. Even if such soil can be recovered under favorable circumstances, it requires winches and sledges or other conveyances. With a sledge of 3 cu m capacity, a farmer must still work 10 hours per day for 6 days with 2 men plus tractor or horse operation for 60 hours for each hectare.

K. Ruppert, Rheinhessen, claims that erosion damage in a single community and a single storm amounted to 300,000 DM; whereas Dr. Banse, Bad Kreuznach, calculated that, during May and June, 1960, 118 tons of dry soil or 130 tons of damp earth were washed away. We believe it superfluous to dwell here on the economic significance of these figures.

Total erosion damage to vineyards is by no means included in these few figures. We have already referred to the loss of nutrients. It is also impossible, even with the best protective structures, to recover and haul back all of the soil washed away. The most valuable soil, the fine soil, is carried away by the runoff water. We are now working with the EAWAG, Eidg. Techn. Hochschule, Zürich, the Director of which is Dr. Jaag, in analyzing the surface water at Eglisau to determine its nutrient content. These figures will be published later in a thesis by a candidate for a Ph D degree at that Institute. They will show how important it is to the Winegrower to prevent or at least sharply reduce the erosion in his vineyards.

Measures Against Erosion Damage

Protective Construction: Ancient vineyards often had terraces and low walls to prevent erosion. When these are maintained and are provided with an erosion ditch on the upper side of the wall which has been periodically emptied, they have fulfilled their purpose well by damming up the surface water flow and thus reducing the formation of gullies. However, such low walls are a handicap to modern mechanical cultivation and they have largely disappeared wherever not absolutely necessary because of terrace construction and steep slopes. They have largely been replaced by cement walls, shelves, and conduits for overflow drainage.

Such works are, however, only feasible in the larger or cooperative vineyards. Such improvements have become commonplace in our region in the last 30 years and most of the vineyards on slopes have become collectivized. A well-planned and -organized union of vineyardists is a prerequisite to the effective prevention of erosion. The barriers, 60-80 m apart, are very effective against erosion. The water velocity is checked and the water retained by them is then discharged through conduits. Ditches are normally dug at a spacing of 30 m and on a slope of about 1 percent or, where the slope is too steep, concrete walls are built to accomplish the same thing. For effectiveness, these ditches or culverts must have a capacity of at least 0.5-1.0 cu m/m of length. Retaining dams should be spaced at distances of 10-20 m in order to trap the fine soil.

Such erosion ditches can only fulfill their purpose if the surface water can be drained off in some way such as by benches of the Sternenhalde type, which have proved exceptionally good, or by sodded runoff ditches along the edges or within the plot. Sodding is advantageous in dissipating the flow of water without erosion. Most modern vineyards, such as those at Eglisau, have conduits to carry off the water. Such drains also exist at Sternenhalde. They have both advantages and disadvantages. While they prevent pollution of the terraces, they may become plugged or break thus causing erosion.

Years of experience with such artificial structures shows that, under normal conditions of weather and precipitation, they will prevent erosion damage. But these concrete shelves, dams, and conduits are very costly. Vineyard improvements, supported by Federal and Canton subsidies, should consist of a good network of erosion dams. Such dams, however, will only fulfill their purpose if they are well maintained. Above all, ditches must be cleaned out and reconditioned after each storm. Otherwise the best erosion structures cannot be adequate. In a year of average precipitation, the maintenance work requires about 50-60 hours of labor per ha, as we have shown in the Sternenhalde trials over a four year period.

Reduction of Erosion by Sodding, Grass Stripping and Green Manuring

It is well known that vineyards overgrown with weeds show much less erosion than freshly-weeded ones. One therefore frequently hears that weeding the vineyards is a disadvantage rather than an advantage. Opinions are divided on this subject. There is a definite erosion-reducing effect but there is also great danger that weeds will proliferate in the soil and make the vineyard difficult to clean out or till the soil. Each vineyard owner must weigh the pros and cons and decide which method he shall take.

Let us now investigate the possibility of avoiding weed overgrowth and yet achieve the same effect by other means. Today it is relatively simple to keep vineyards weed-free by the use of a chemical weedkiller. Green manuring is a primary preventive measure. The seeding of green plants is becoming even more important in modern vine-growing with its wide spacing. Besides taking care of the humus requirements of the vineyard soil, green manuring should also have an erosion-preventive effect. Such effect is only possible if seeding can be done in the spring and not, as has been common, in the month of August. It is our opinion that seeding green plants in the spring can be done without effecting the quality of the grapes. Testing is in progress in many experiment stations and commercial installations so that conclusive results concerning this question may be obtained. Erosion is unquestionably reduced greatly by appropriate green manuring.

Partial effects have been obtained for years by establishing cross-strips of white clover or other green manuring plants on the steep slopes of the Sternenhalde and also in some commercial vineyards. Such strips should be planted across the slopes and they should be 5-8 m apart and about 1 m wide. During plowing, the plow is lifted over these strips. After 2-3 years, when the strips are plowed under, others are planted in different cross-rows. These sod strips act as stops to the formation of rainwater gullies. They have proven very successful to date. This function is only fully attained in conjunction with the use of ditches and runoff pipes.

Total sodding of the slope is the most effective erosion preventive. Grape quality necessitates use of a sprinkler system or expectation of very high precipitation, also the use of high wire culture or high growth. Fertilization must be given greatest attention if sodding is used. We shall not consider this further as we are only considering the danger of erosion. It is certain that this method provides the best erosion prevention.

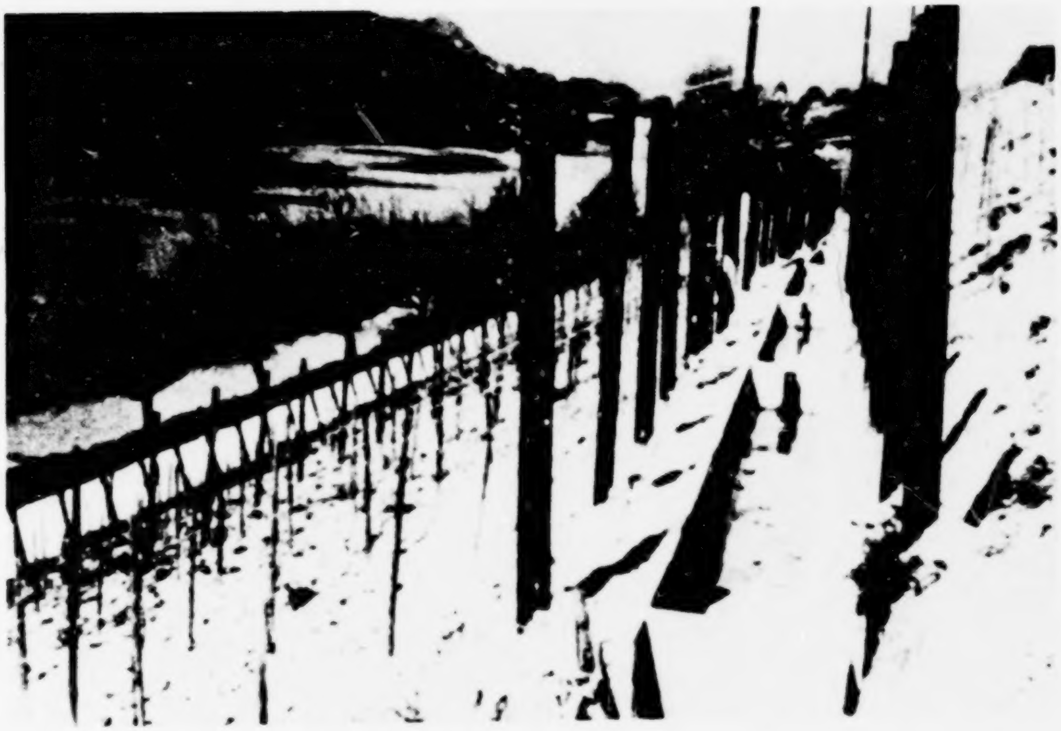
Prevention or Reduction of Erosion by Covering Vineyards with Humus

This method is often discussed in today's practice. It deals with an ancient problem in vineyards which, however, has gained recent attention, especially in connection with the use of refuse compost made from the solid wastes of cities. It is well known that the need for humus is especially great in vineyards and that most vineyard soils have shown a reduction of humus content. With this there is greater danger of erosion as shown both by experience and by experimentation.

Schrader places the humus requirement for vineyards at between 4 and 6 tons/hectare; with light or rocky soils, up to double this amount may be required. Traditionally, this requirement was met by application of 40-60 tons/ha of manure every 3-4 years. This was practically the only source of humus, ignoring possible weed overgrowth, because pruned vines and branches were usually removed from the vineyard.

Great specialization has occurred in our vineyards in past years, i.e., more and more winegrowers changed from mixed to pure vineyard culture. This reduced the available manure. Additional purchase of natural manures is further hindered by the over-all decline in cattle raising. For these reasons, efforts are being made to replace manure with compost or with green manures, as previously described. As this compost cannot be produced by the individual winegrower, it is becoming increasingly available as refuse or garbage compost made in commercial or municipal refuse utilization plants. Results of some specific experiments done by us in Eglisau will be discussed later as to the influence of refuse compost against erosion. Director Klenk of the Lehr-und Versuchsanstalt Weinsberg was the originator of this application of refuse compost. He has used self-made refuse compost in vineyards for over 10 years. His practical demonstrations of the erosion-preventive effects of this material have been very convincing and instructional. For example, he removed 12 terrace walls in a large new planting on a steep slope and then applied by deep furrowing 3 cu m/are of refuse compost (1 are = 100 m^2) and followed every other year with 1-2 cu m. He achieved better results by this, even through thunderstorms, than his neighbors with their walls.

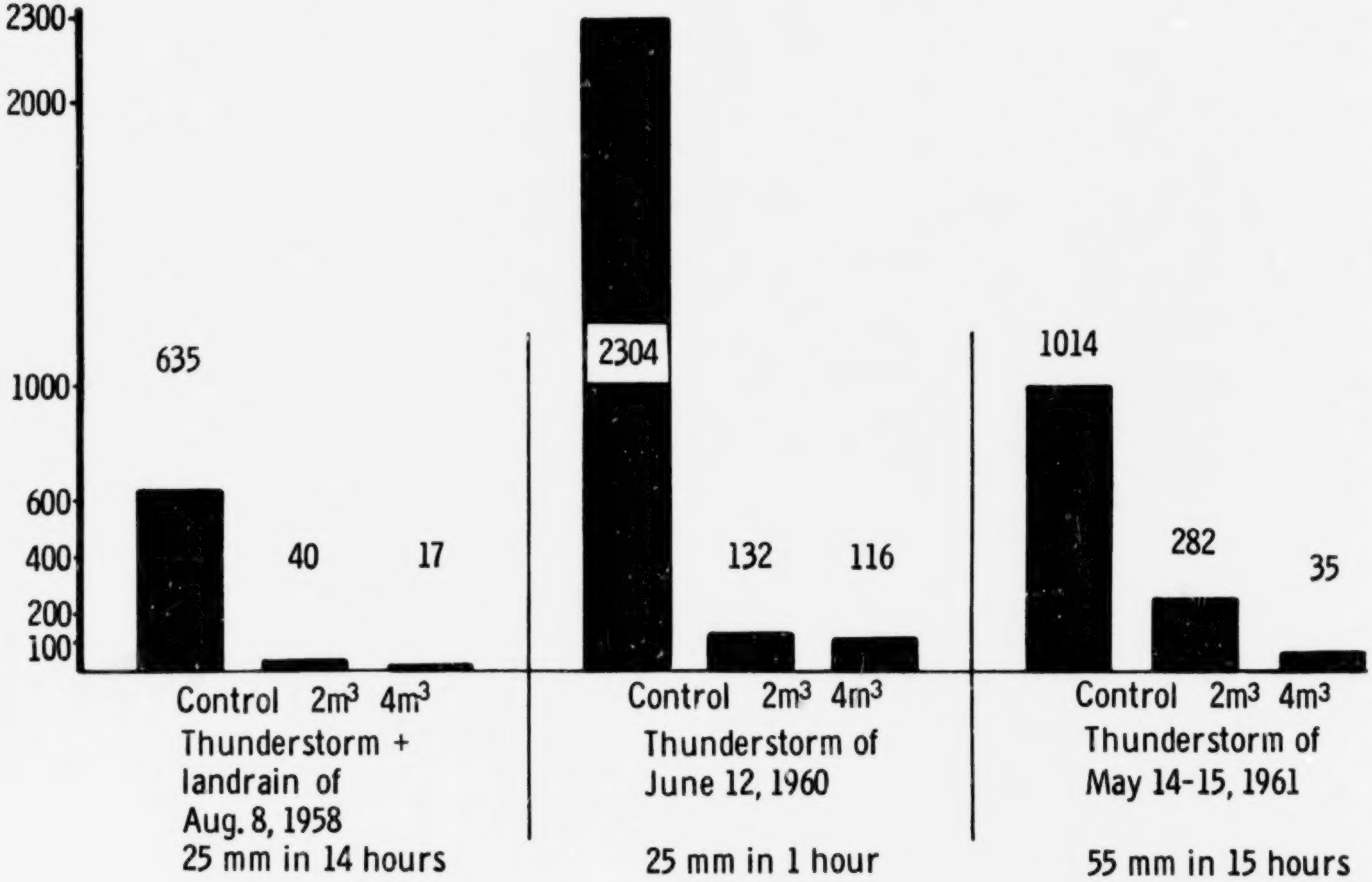
Stimulated by the results of Klenk at Weinsberg, we checked, with the cooperation of EAWAG and the Eidg. Versuchsanstalt Oerlikon, the influence of compost on erosion. This has been done since 1958 on a slope with 50 - 60 percent inclination at Eglisau growing Riesling and Sylvaner grapes on wires. In this installation distances are 1.6 m between rows and 1.2 m between plants. The experiment included 3 duplicate plots of a length of about 28 m and with 4 rows of vines or an area of 1.8 are. As shown in Figure 1 this area has a high erosion potential. Two plots were treated only with mineral fertilizer, two with 2 cu m/are of compost in 1958 and 1 m^3 in 1960, and two with 4 cu m/are in 1958 and 2 cu m in 1960. The second application was therefore half that of the first and was made after two years. Labor for applying compost was 5 hours/are. Earth sleds and pushcarts were used which were pulled by a power tow rope. The upper ends of the plots were blocked off with boards so that accurate collections of eroded soil could be made. At the bottom of the plots were concrete boxes which collected all eroded material for separate measurement from each plot. In addition all cover water was caught in a trench and the eroded soil nutrients were measured. I regret that I do not have the latest data today. After each storm the eroded earth is removed and its wet and dry weight determined. This is the first measurement of its type made to our knowledge in a large experiment. The fine soil eroded in three heavy thunderstorms during 1958-61 was measured and is shown in the table.



Wet-Weight of Eroded Soil, Kg/3.6 ares

	Total Precipitation in mm	Untreated Kg	2 m^3 Compost/Are Kg	4 m^3 Compost/Are Kg
Thunderstorm and Rain of 8/8/58	25	635	40	17
Thunderstorm of 6/12/60	25	2304	132	116
Thunderstorm of 5/14-15/61	55	1014	282	75
Total	105	3953	454	208

Compost Experiment at Eglisau
net-weight of eroded soil in kg / 3.6 are.



The following conclusions are drawn from these results:

a) Heavy thunderstorms on steep vineyard slopes cause a tremendous loss of the most valuable soil. Untreated plots up to 33 cu m/ha were eroded in one thunderstorm. The totals of fine soil and nutrients lost and the amounts of labor and expenditures that winegrowers must apply to partially retrieve this valuable soil can only be indicated in part.

b) The effect of refuse compost in prevention of erosion is striking and interesting for practical application; success is increased directly with the amount of compost applied.

c) The favorable effect of the first compost application lasted for two years and the difference between 2 and 4 cu m/are was moderate.

There was, however, a measureable difference between 2 and 4 cu m. The effective duration of the second application is considerably longer, based on data collected since the spring of 1960. It was observed that the ground was much more saturated in the fall of 1961 than in the fall of 1959 where compost was applied. At this time we speak only of the effective duration of humus relating to erosion prevention. The fact that an extensive effective duration of improved soil characteristics is obtained with the use of humus is shown in a report of O. Heusser on "Mitteilungen des Vereins Zur Förderung der Moorkulturen." During 1960 soil samples were taken by him from experimental plots which had been treated in 1921, 40 years ago, with 20 tons/ha of brown coal. He reported: "The expert had the opportunity in 1960, after 40 years, to visit these areas and to obtain soil samples. Our physical and chemical examinations showed that a very favorable influence of the decayed refuse upon the granular structure can be shown even after 40 years to a depth of 40 cm." (See IRGR Information Bulletin No. 12.)

We will not examine further the physical soil improvement which influences soil cultivation, utilization of walkways, water-holding capacity, etc. We only point out that similar improvements were observed in the experiments at Eglisau.

Another practical example of the effect of refuse compost against erosion in vineyards was observed by us in a nursery in Leutschen, Schwyz Canton (Switzerland). This vineyard was exposed to extraordinary heavy and frequent erosions. In the spring of 1959 we applied 2 cu m/are of refuse compost. Costs of transporting and spreading over a 20-are lot with a 30 percent slope were:

4.58	Sw. Francs for transport
5.51	Sw. Francs for spreading
10.09	SW. Francs/m^3 of compost

Application was made by foreign labor. The success against erosion was very good in 1960 while heavy damage occurred in a neighboring lot. But the effect was considerably reduced in the following year. As the available humus content, due to heavy erosion in previous years, was very slight, a heavier application of compost would probably have been necessary to achieve more lasting success.

Klenk recommended in publications that refuse compost be applied with deep-furrowing of the soil. We conducted such an experiment on a steep slope in the Kob vineyard in Rheinan. An application of 3 cu m/are of compost was made with deep-furrowing in 1958. The soil there is gravelly and porous. In contrast with Eglisau, the compost here was worked into the soil through furrowing. Results did not satisfy us as we could not observe any reduction in the erosion hazard.

If we should formulate some requirements which a practical winegrower should specify of refuse compost, they would be:

The compost should be neutral, that is with a pH of 6-7. It must be weed free and its physical characteristics should permit easy transportation and spreading in the vineyards. Its nutrients should be equivalent to that of a good manure. It must be free of plant material as well as glass splinters and non-degradable constituents. The decomposition of the compost should be completely finished. We would like to mention the opinion of Dr. Gertel, Bernkastel, who reasons that the desirable effect on prevention of erosion is due to the clay-humus combinations which are formed by adding humus to soil. These combinations are very stable against erosion and flooding. They also seem to be able to catch and retain much more water.

Procurement of Humus

Following are the most important sources of humus for vineyards: Peat, in the form of peat moss for light soils and peat chips or chaff for heavy, binding soils, will probably be considered only as a source of permanent humus. Nutrient humus then is only obtained when it is fortified such as by addition of manure or by overpouring liquid manure. This material should be quite valuable if stored for a time prior to application. Straw or cut straw is often recommended for use in conjunction with green-manuring and as a light mulch. The use of straw is less advantageous on strongly alkaline soils as are mostly found in our areas of vinegrowing, because large quantities of carbonic acid (CO_2) are obtained in the decomposition of the straw. This acid could increase the activity of the alkalinity. In our experience a straw cover in spring reduces warming of the ground greatly and delays the growth and bloom. In our climate this must be regarded as a disadvantage. In the use of straw as a source of humus, care must be taken to insure a sufficient nitrogen fertilization.

Preparation of Compost in Private Vineyards

The possibility of obtaining humus should be utilized more than it has in the past. There are vineyards today where manure is not used but the manure is first composted and then spread as cured compost. Advantages of this procedure will not be discussed. Materials for self-composting could be: vine wood, refuse of all kinds, grape skins, etc. We have had favorable experience in composting vine woods. We achieved finished vine wood compost in a half year in 1960. We used a machine which shredded the vine wood. The first stacking of the compost windrow consisted of alternate layers of shredded vines with manure, grape skins or other refuse. Before the second stacking, the materials are passed through the shredder and are therefore well mixed. In this way it was possible to add many valuable nutrients to the vineyard soil which were formerly lost.

Buying and utilizing refuse compost and sewage sludge-refuse compost should prove to be a major future source for providing the humus needed in many vineyards if the material is well mixed and decomposed.

Construction of compost plants for use of the refuse of industry and cities is gaining more and more in importance. These plants will have a great interest in finding markets for their quantities of compost. We believe that vineyards will play a great part in this respect. Prerequisites will be the preparation of a well decomposed, spreadable compost which can be brought at a reasonable price. We think the price of compost should be on a comparable level to that of manure. We estimate the cost of manure, including transportation and spreading, as around 20 Sw. francs per cu m. This figure will vary greatly with different areas and conditions. Considering this, then the price of compost should not be over 10 Sw. francs when purchased at the plant. It is too bad that today's prices are still considerably higher than that. This is detrimental to the use of the material in vineyards. Also, in the advertisements of some composters, there are still a lot of wonder cures such as trace elements, bacteria, growth stimulants, etc., attributed to composts. A more rational conclusion in this regard is offered by Andres, Bad Kreuznach, who states at the conclusion of an interesting article: "Composts from refuse and sewage sludge are not nutrient fertilizers but they are soil improvement materials." It is desirable to establish uniform shipping prices which should be graduated as to distance from plant to vineyard.

Influence of Soil Cultivation on Erosion

A few points will be mentioned concerning the influence of soil cultivation upon the prevention of erosion. Previously, we mentioned the building of erosion ditches which is a necessity in all endangered locations.

Contour terracing is one of the most effective measures against erosion and it is practiced to a great extent in our Southern Tessin Canton.

There is a terrace built for every row of vines. The steep slope of the terrace is covered with grass. The width of these terraces is varied according to the terrain. Similar contour terraces are found in Southern Tyrolia where the Pergola system is used. This appears to be the only method by which complete erosion can be prevented in small plots which do not have erosion ditches. This Tessiner terracing is strongly recommended on extremely steep slopes.

It is also possible to mix the soil with coarse materials such as gravel, slate, coke, etc. We remember this practice in areas of Wallis, Mosel, and elsewhere. Although this method is rather expensive, especially in terraced lots without secondary roads, it is very effective against erosion. Other advantages cannot be discussed here.

It was the practice in our area to cover the vineyards in the summer with bedding manure to prevent erosion. This is impractical today if only due to the shortage of labor. The benefits were insufficient during heavy thunder storms.

Summary

Erosion in vineyards due to precipitation has been discussed and its effect demonstrated by actual measurements. The great interest that winegrowers have in eliminating or reducing soil erosion was then shown. Control possibilities include: construction of artificial erosion stops, green manuring, sodding or sod strips, increasing the humus content of the soil, terracing steep slopes, or the use of coarse materials. Several ways of increasing the soil humus content were mentioned.

The utilization of refuse composts in vine growing was discussed more fully. Their positive effect against erosion was proven by measurements. It was concluded that, if refuse compost prices were economical, the winegrower should have great interest in its use.

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NO. 16

DECEMBER 1962

Ferguson, Brooks & Kelly and Warren L. Armstrong, translators
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1. The Refuse Problem of Swiss Resort Towns by Dr. H. E. Vogel, Director, Swiss Water Pollution Control Association, Zurich.

Today's age of technical advancement and increasing populations is marked, among other things by a tremendous increase in residential as well as industrial and commercial refuse.

Refuse removal in resort towns presents a problem which differs sharply from that in other communities for the following reasons:

First: The refuse of resort towns comes not only from the permanent residents but also from the tourists and hotel employees during the tourist season.

Second: Many Swiss resort towns are located in favorable climates but are in unfavorable locations regarding traffic problems, especially in relation to refuse collection.

Third: In most of these towns the tourist trade is the only real source of income, and this for only part of the year. The ever-sharpening competition with foreign tourist resorts requires that all tourist facilities be kept up to the most modern standards. Also, debt recovery from the depression of the thirties and from the war years 1939-1945 is a very serious problem. When all this is considered, it is only natural that solution of the refuse problem received insufficient attention. This is not only the case in resort towns, but very common everywhere. The problem in resorts is aggravated by the fact that a relatively small group of residents has to pay the cost of refuse removal during the tourist season and often meets strong psychological problems in attempts to have these costs borne by the tourists.

Finally, it must be considered that most foreign hotel employees are not familiar with local sanitary standards and that it is also difficult to require tenants of rental cabins during their vacations to conform to hygienic standards. After complaints about intolerable conditions of refuse disposal had come to us through newspapers and by direct letters to the Swiss Water Pollution Control Association, we were charged by Dr. O. Jaag, President of the Association, with responsibility to conduct an investigation of local conditions of refuse removal in the major Swiss tourist centers.

In order not to conduct our investigation haphazardly and to be sure that we obtained a representative average of the tourist towns, we calculated a tourist intensity coefficient in which we considered the number of tourist beds and the total permanent population.

From 42 cities having the higher intensity coefficients, we chose 36 centers to be included in the investigation. We were aware that we obtained from this arbitrary selection only a sample of one of the various types of vacation and tourist trade, that is, based on hotel

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guests alone; but we considered in the investigation all other categories of guests such as guests of private homes, in apartments and cabins, in camping places, in health resorts, and educational institutions in accordance with their relative occurrence.

The questions posed during our investigation were selected to treat correctly the varied racial-geographical, legal and financial aspects of the tourist problem complex that might have an influence on the collection, haul, and disposal of residential refuse:

a. Population structure, location, and their changes;
b. Scope, structure, and developmental changes in hotels, apartments, cabins, campgrounds, health resorts, and institutions, including changes in population and personnel;
c. Quantity and type of domestic refuse, seasonal changes;
d. Refuse transportation, the topography of routes;
e. Refuse deposition, authorized and indiscriminate dumping;
f. Future planning of the refuse organization;
g. Refuse regulations, regulation of collection times and districts;
h. Refuse collection costs, resulting community income;
i. Resulting community preparation for refuse removal; and
j. Community tax income.

During the investigation we personally contacted mayors, city clerks, public works directors, city engineers and local police departments. We also contacted the local tourist bureaus.

We found that the refuse situation is still very bad in most tourist centers. Even though larger communities have organized refuse removal, at least within the city limits, large quantities of refuse are not disposed of adequately. There are large refuse deposits, for example, on lake shores which disseminate unpleasant odors and draw plagues of flies, rats and crows.

In communities located on mountain slopes, refuse, containing butchers' offal among other things, is often dumped directly from main highways onto refuse slopes. These slopes which often attain a height of 100-150 meters, frequently ignite themselves with the resulting smoke polluting the air of entire communities. The wastes of these slopes progress deeper and deeper into the forests beneath or fall from the mountainside into lower agricultural areas.

In other communities the refuse is simply dumped into nearby creeks and rivers without any regard for the fact that these waters might later be used for drinking purposes. It is then the unpleasant task of the downstream population to fish out cans and even more unappetizing materials from the water.

In many places indiscriminate dumping has grown to an urgent problem.

It must be mentioned in connection with this problem that Swiss tourist towns have been swamped with development during the last decade and are now developing so rapidly that the direction and extent cannot even be guessed. In this period the number of hotel rooms has doubled and, in some areas, even tripled.

Just as hotel vacationing has increased, so has vacationing in private housing and in camping. In some communities the number of lodgings in vacation apartments has surpassed that of resort hotels. This is the situation in Adelboden, Villars, Verbier, Lenzerheide, Klosters, etc. An ever-increasing number of summer homes are being bought by people from the lowlands and even from foreign countries. Some apartments are also sold on a cooperative basis.

Very often we find a shrinking local population contrasted by a saturation of foreign elements. As an example, one community, Arosa, has a local population of 2,600 but during the hotel season the population reaches 12,000, including guests and employees.

The strangers bring with them different customs, particularly different consumption habits. This creates a tremendous increase in consumer goods at the tourist centers. The local population adapts itself sooner or later to the new living conditions. The increasing automobile tourism, to which door upon door is opened with the expansion of our street systems, also greatly increases the trend toward urbanization.

These developments act very heavily upon the refuse problem of the tourist towns and increase the residential refuse in practically geometrical proportion. The changeover to electric stoves and oil furnaces also plays an important role in that it frees great quantities of wastepaper. The following are just a few examples of the recorded totals of refuse per year: in Montreux, 19,500 cu.m.; Davos, 15,000 cu.m.; Zermatt, 13,000 cu.m.; Arosa, 11,000 cu.m.; Interlaken, 10,000 cu.m.; Grindelwald, 9,000 cu.m.

Cabins, vacation apartments and camping places are especially responsible for the creation of such quantities of refuse. It is very sad that these changes are largely responsible for the ugly and scattered refuse dumps which deface forest edges, small ravines, alpine meadows and other beautiful sites.

We determined in comparitive studies that there is a constant ratio between the amount of refuse and the number of lodgings in the various guest categories. The quantity of refuse per guest per day of lodging amounts to two or more times that of a local resident.

The financial means by which the unbearable refuse problem of these tourist centers can be solved cannot very often be provided by the local population due to the many other expenses of new construction and scenic improvements.

Costs of refuse removal per capita per year for local residents amounted to: 16.00 Swiss francs (Fr.) in Flims, 20.40 Fr. in Lenzerheide, 21.20 Fr. in Arosa, 13.60 Fr. in Davos, 21.30 Fr. in St. Moritz, 13.60 Fr. in Pontresina, 10.60 Fr. in Interlaken, 14.20 Fr. in Wengen, 13.40 Fr. in Leysin, 17.50 Fr. in Villars, and 38.50 Fr. in Verbier. Even though refuse removal is regulated in most of these towns, proper disposal of residential refuse in suitable plants has not yet been actually started.

In middle-sized Swiss towns without strongly developed tourist trade, these costs are very low without exception. From the stated costs in resort towns it should be obvious that the necessary means to cover the cost of refuse removal cannot be obtained solely through a resort tax from the tourists.

There are a few tourist towns, such as Verbier, Grindelwald and Davos, which have found satisfactory solutions to their problems even though we must designate the refuse problems of most Swiss resorts as very urgent. Some of them are dumping their refuse in isolated stone quarries where contamination of groundwater and air are not hazards; others have incinerators for their refuse.

There are projects planned to collectivize whole valleys, or at least central regions, which would then deliver their refuse to common refuse utilization or incineration plants, even though this would still be rather expensive for the smaller cooperatives. Such associations are planned for the upper Swiss shore of Lake Geneva, the Sottoceneri (area around Lugano), the area of Locarno-Ascona, the Oberengadin, the Prättigau (including the monstery), etc.

The urgency of solution of the refuse problem in Switzerland must, however, be emphasized and if we do not act promptly we will be faced with an avalanche of refuse in a few years and our towns will have to struggle under much less favorable circumstances.

In this struggle we will not only have to cope with financial solutions to the refuse problem but we will also have to improve on disease prevention. In this the education of the tourist, particularly campers and those in cabins, is an extremely important part.

We believe, however, that we may correctly assume that there are many associations and institutions in Switzerland which will give us much help in our efforts to solve this problem.

2. New Guidelines for the Composting of Raw Ground Refuse in the Netherlands by Engr. B. Teensma, Stichting "Compost," Amsterdam.

Introduction: The purpose of using compost is to bring about an improvement in growth conditions (especially an improvement in soil structure) for cultivated plants. The compost user therefore expects that the plants he raises will react positively to a compost application. This positive reaction could be a higher yield, improved quality, or both. If no positive result is indicated, the conclusion can be drawn that the treated soil was already in satisfactory condition and did not require compost addition. Then the next application of compost would be delayed for several years. The trust in compost, however, will be maintained.

If, on the other hand, negative results are obtained after compost application, particularly if compost-loving plants are grown, then the problem takes on a different aspect. Then even a regular compost user will lose his confidence in that compost and will turn to using other organic fertilizers. Such negative results should be avoided under all circumstances.

In the spring of 1960 we received some negative reports of compost use with lettuce and tomatoes from the Westland (a truck-farming area between Rotterdam and The Hague). The causes of the damage were very closely checked by us. We determined that composts, which were prepared according to the guidelines of 1955, exhibited partial plant-damaging characteristics. The characteristics of the product, and also of the refuse, had changed so much in the last few years (much more paper and therefore a much higher C/N than previously) that the old guidelines were no longer valid.*

New experiments were therefore conducted to determine the criteria for new composting guidelines which will assure excellent compost quality under these new conditions.

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* The old guidelines, based on extensive composting experiments, were as follows:

1) The height of the windrows should not be more than two meters.
2) Moisture content of the material during stacking should not be more than 50 percent.
3) Duration of decomposition for winter refuse should be at least 8 weeks and for summer refuse at least 12 weeks.
4) During decomposition the windrow should be turned once preferably after about 4 weeks.

The Experiments and Their Results

The experiments, conducted during 1960-1961, by the composting plants at Delft and Schiedam, comprised the following:

1. Influence of turning (with tractor loader, grab crane or moving belt) on the quality of the compost. Time, frequency, and method of turning were varied.
2. Checking of different types of compost in greenhouse experiments with young tomato plants. A mixture of 75 percent soil and 25 percent compost by volume was used.

Results of the greenhouse experiments were readily observed after only 14 days and answered the implied questions. A plant-damaging effect had a twofold cause:

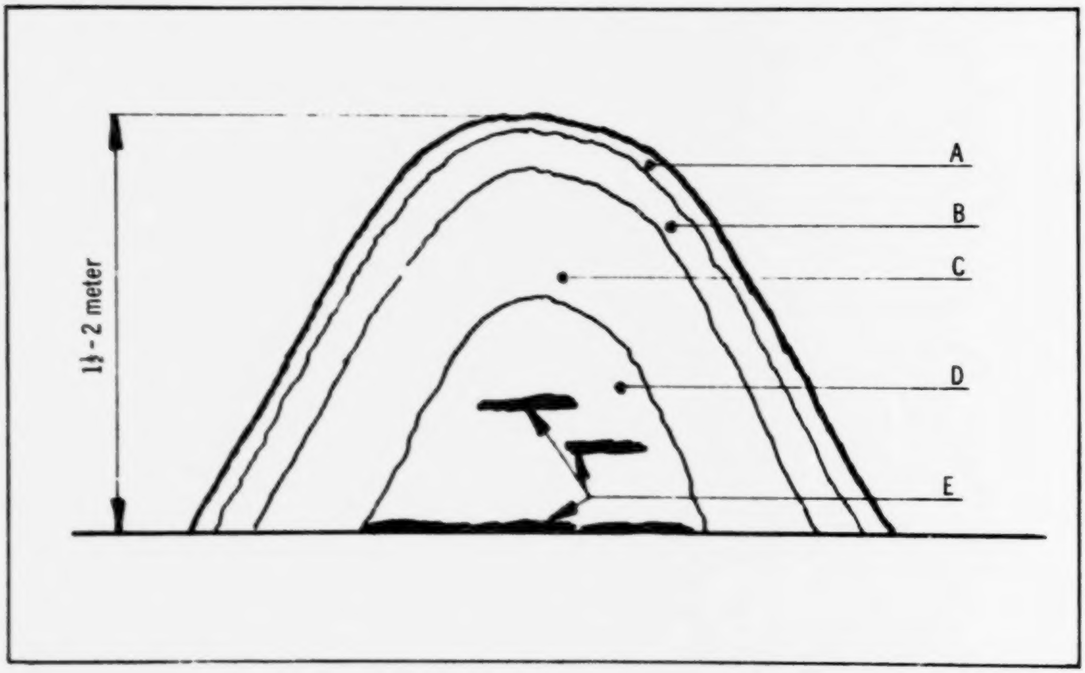
1. Inadequate maturity of the compost (too high a C/N ratio). This was shown by a pale leaf color and delayed growth due to lack of nitrogen.
2. Presence of toxic substance (butyric acid) in the compost. In this case the leaves wilted after 24 hours and the plants died.

Age of the compost is not a measure of harmfulness. A two and one-half month old compost can be satisfactory whereas an eight month old one can be very harmful. The determining factor is the proper degree of decomposition.

The pH value is a good guide for a relatively old compost. Raw refuse in Holland has a pH value of 7.3 to 7.8. The material (except for an outer layer of 5 cm thickness) showed an acid reaction four days after stacking, that is a pH between 4.5 and 6.0. The value slowly rises to and above pH 7 during the decomposition process. If the pH of the compost is near 7, it should be satisfactory. Harmful compost generally exhibits an acid reaction, that is weakly acid (pH 6-6.5); if it is insufficiently decomposed and strongly acid (pH under 5), then it is definitely poisonous and contains butyric acid.

We observed that harmful compost exists only in very localized parts of the compost windrow. Definite and easily recognized zones and layers were found only 2-3 weeks after stacking. These result because of greatly differing conditions in various parts of the windrow regarding temperature and oxygen and moisture content. Thus the decomposition process is quite different in the various parts of the windrow.

These zones are shown in the following diagram. This is a windrow of summer refuse after a period of 4-6 weeks. These zones are more definite in summer refuse than in winter refuse. The windrow was never turned.



Zone A

Thickness: About 10 cm. The outside is covered with a 1-cm crust.
Color: Dark brown.
Odor: Earth-like.
Temperature: 25-35° C.
pH value: 7-7.5.
Moisture content: Varies greatly with rainfall, generally wetter than zone B.
Decomposition: Good, almost no undecomposed paper present.

Zone B

Thickness: 15-25 cm.
Color: Gray-white, moldy.
Odor: Musty, moldy.
Temperature: Up to 45° C.
pH value: Over 8.
Moisture content: Low, less than 40%.
Decomposition: Not as good as zone A, contains bits of paper. The compost in this layer breaks up into clods and can be wetted only with difficulty.

Zone C

Thickness: 50-75 cm.
Color: Light brown.
Odor: Slightly acid.
Temperature: Very high, 55-75° C.
pH value: 6-6.5.
Moisture content: Very low, about 30%.
Decomposition: Slight, contains very much untouched paper.

Zone D

Thickness: Varying, from C to bottom.
Color: Very dark, nearly black.
Odor: Slimy, not unpleasant.
Temperature: Low, 28-40° C.
pH value: Mostly above 8.
Moisture content: High, 50-55%.
Decomposition: Relatively good, better than B and C.

Zone E

Does not always occur, is limited to a thin, 5-10 cm, layer just above the ground. Exists sometimes as small areas in the black compost of zone D.
Color: Gray-green.
Odor: Strongly acid, nauseating.
Temperature: Low, 28-40° C.
pH value: Very low, about 5, sometimes lower.
Moisture content: High, above 50%.
Decomposition: Very slight, practically undecomposed.
Compost from this zone contains free butyric acid in amounts up to 3%.

The composts from zones C and E are plant damaging as shown by the previously mentioned greenhouse experiments. Compost from zone C caused a delay in plant growth and a pale leaf color from a lack of nitrogen because this compost was insufficiently decomposed and led to a nitrogen tie-up.

The gray-green compost from zone E acted poisonously and caused wilted leaves on the plants in a short time.

The composts from zones A, B, and D were not harmful. At times a slight tie-up of nitrogen was observed to be caused by the compost of zone B.

It is therefore necessary to prevent the use of the harmful material from zones C and E on fields. Extreme conditions are prevalent in both zones during the decomposition period. Zone C is quite dry as much of the water evaporates due to the high temperature. This slows down or completely stops the microbial activity as noted by a decrease in temperature. It might be thought that it is possible to control the high temperature by regular additions of water. But it has been found that it is almost impossible to moisten the material of zone C because the next higher layer, B, is water repellent and does not permit penetration of the water. It might be possible to blow in air but this is not simple and besides that would increase evaporation and drying more than high temperatures.

Based on our experience, it is hardly possible to prevent the formation of zone C. But one can make sure that it exists for only a short time. The windrow should be turned shortly after its formation. Turning must be continued (repeated) until this zone disappears. It is therefore impossible to determine the number of turnings necessary. The same is true for zone E in which extreme anaerobic conditions exist due to the heavy pressure.

Turning is therefore only necessary for zones C and E. Zones A, B, and D produce a very usable compost even without turning. In contrast, zones C and E never produce good compost. Even after a year it can still be damaging.

When definite zones are no longer evident in the windrow, the compost is finished. At this state the compost is a lighter color on the outside than on the inside where the material is more moist. The transition from light to dark compost is gradual and not sharply defined. Such compost can be stored in large piles if necessary.

Turning the windrow only one time has been the rule up to now. However, this is inadequate with the changed quality of today's refuse. It is impossible to determine in advance the number of turnings that will be necessary. The windrows must be regularly controlled by the use of profile cuttings. When definite zones are visible the windrow must be turned until the zones disappear. With winter refuse a single turning is generally sufficient. With summer refuse two turnings are still not enough as a rule.

Our experiments showed that turning with a shovel loader is less favorable than turning with a grab crane. The best results were obtained by turning with a belt comveyor having a hammermill (concussion mill) with a few spikes (teeth) mounted on the upper end to break up all clumps of compost. We were able to reduce the number of turnings with the help of this machine. Two composting plants in the Netherlands already have such a turning machine. Other plants will also use it in the future.

It has been found that an addition of 10-20 percent by volume of finished compost or peat to the raw refuse will greatly aid the composting.

New Composting Guidelines

Based on these experiments and the experiences of the Dutch compost plants, the following guidelines were set up:

1. Compost windrows should not be higher than 2 meters. The tops of the windrows should be rounded or roof-shaped to permit rain runoff. The windrows must be separated. The windrow area must be well drained; puddle formation after rains must be avoided. The moisture content of the raw refuse at the time of stacking must be between 50 and 55 percent (better too wet than too dry).

2. The interior of all windrows must be checked every week. When zones have been formed, the windrows must be turned (as a rule about 2-3 weeks to the first time). Checks must be continued after turning. As soon as new zones form, turn until they disappear. When this stage is achieved, the compost is finished and may be piled in large stacks.

3. We recommend the use of a belt conveyor with a nail covered concussion mill as a turning machine.

4. We recommend an addition of 10-20 percent by volume of ripe compost or peat to the raw refuse.

3. Hygienic Criteria for the Evaluation of Refuse Compost by Dr. Edita Parrakova, Institut of Hygiene, Bratislava, Czechoslovakia.

The hygienic (sanitary) problems are not completely solved with the removal, and possible utilization, of the refuse from cities and villages. Refuse is an excellent medium in which pathogenic microorganisms survive and intestinal parasites prevail in certain life stages. It is a breeding ground and attractant to various insects, especially flies, which are the most prevalent carriers of practically all bacterial diseases. Besides that, it is the favorite harborage for rodents (rats, mice, etc.) who find in it conditions favorable for their development. For these reasons it is necessary to consider certain technical requirements in the processing of refuse to compost. Many composting systems have been described and used in practice which guarantee the elimination of all pathogenic microorganisms and intestinal parasites and exclude the presence of flies and rodents. We produce Vitahums (organic fertilizer) on a large scale.

Several criteria for the evaluation of composts from a hygienic standpoint were developed to consider the reliable elimination of the possibility of continued contamination by fertilizing with compost or through its transportation. The composts used in gardening are of primary concern here. Chemical and biological indicators were used in the development of the hygienic criteria. The following were determined from chemical analysis: moisture content, hydrogen ion concentration, organic matter, total nitrogen, organic carbon, ammonia, and phosphates. The chemical analysis of compost showed its fertilizing qualities and partially revealed the changes in the organic matter in addition to supplementing and guiding the biological analysis. The content of ammonia was used as a hygienic indicator, the higher concentrations indicating undesirable processes in the decomposition of composting material and its presence acting as an important insect attractant and inducing egg deposition. From these facts one can consider it proper to use the ammonia content as a hygienic indicator.

Definite emphasis is placed on microbiological methods in the biological analysis. The greatest emphasis of all is placed on determination of the coli titer. It is known that, in the process of decomposition of organic matter by composting, a great reduction, if not elimination, of coliform bacteria occurs or the citrate-positive forms predominate. The destruction of coliform bacteria permit the assumption that the less resistant pathogenic bacteria are also destroyed. A further factor is that bacteria of the enterococcus group cannot reproduce in this environment but merely exist and therefore die off faster than the coliforms. These organisms are very important from a hygienic standpoint because they are intimately associated with the pathogenic intestinal flora and their survival time is between that of the salmonella and the coliforms. In addition to these two factors, there should be conducted a titration for clostridium perfringens, counts of mesophilic bacteria, mold fungi, and Actinomycetes; and a titration of nitrifying microorganisms. The microbe counts and the titer of nitrifiers act more as guiding indicators and serve in following the metabolic processes during the decomposition of organic matter.

Based on our results, we recommend that the organic fertilizer be judged from the following hygienic viewpoint. The hygienic control necessitates determining the ammonia content and the coli titer. Both of these analyses are carried out by simple and easy methods. The research, conducted over several years, revealed that an unobjectionable product will have an ammonia content of 1-2 percent of the total nitrogen (maximum of 3 percent) and a corresponding coli titer of 10^{-2} (0.01), this only in citrate-positive forms. These chemical and biological indicators are very important for total evaluation of the product and as it relates to the health of the worker coming in contact with the material during its production.

Hygienic control of the product ensures the prevention of soil contamination with epidemiological factors when treated with these organic fertilizers.

4. Continuous Thermophilic Composting (summary of three articles by Dr. K. L. Schulze, East Lansing, Michigan, as listed below) by Dr. W. Obrist, EAWAG, Zürich.

An experimental plant, consisting of a horizontally rotating drum of 208-liter capacity equipped with a gas meter, registering thermometer and oxygen analyzer, was in continuous operation under thermophilic conditions for 176 days. Temperature of the decomposing material varied from 53° to 70° C. A mixture of shredded refuse and dewatered sewage sludge was used as raw material. In order to achieve continuous decomposition, it was necessary to reduce the moisture content and the density of the mixture by addition of dry wastes, shredded paper, wood, cereal wastes, or air-dried sewage sludge. Mixtures with a moisture content of 50 to 60 percent, a density of 0.40 to 0.48, and a free air space of 30 percent of the total drum volume were found to be best suited.

Fresh material was added daily or every other day in amounts up to 18 percent of the total wet weight. Decomposed material was removed before the addition, in amounts of 40 to 60 percent, of the added raw material. Weight reduction through losses of volatile substances (CO_2, H_2O) was from 36.8 to 45.2 percent and this occurred in both the 1- and 2-day addition cycles. Average retention in the drum varied from 7 days in the daily cycle to 18 days in the 2-day cycle. The continuous air supply was so regulated that the discharged air had an oxygen content of not less than 5 percent; it was determined from this that between 63 and 140 liters of air was used per day per kg of volatile matter. The pH value of decomposing compost remained above 7 when additions of raw material were less than 18 percent. The pH decreased to about 6 with peak additions of 18 percent. Contrary to expectation the activity of the thermophilic flora was not diminished by this.

The material removed from the drum had a dark brown color and an odor similar to fermenting tobacco and did not attract flies. The density increased to 0.56-0.61 and the moisture content remained about the same. The material had a crumbly structure after it was stored for 2-3 weeks in open containers, had a pH of between 8 and 9, showed no more heat production, and had a pleasant earthy odor. The practical aspects and possible development of this new composting method are discussed.

References:

(1) Schulze, K. L. Rate of Oxgen Consumption and Respiratory Quotients during the Aerobic Decomposition of a Synthetic Garbage. *Compost Science* 1(1)36-40, Spring 1960.

(2) Schulze, K. L. *Aerobic Decomposition of Organic Waste Materials*. Final report. Michigan State University, East Lansing, Michigan 1961.

(3) Schulze, K. L. Continuous Thermophilic Composting. *Applied Microbiology* 10(2)108-122, 1962.

5. *Abstracts from the American Magazine "Compost Science"* summarized by J. S. Wiley, San Francisco, California.

Vol. 2, No. 2, Summer 1961--"Relationship between moisture content and activity of finished compost." K. L. Schulze.

The utilization of oxgen by small amounts of finished compost was measured by means of the Warburg method at various moisture contents. Weight and volume of small amounts of finely ground material were measured. Determination of the specific gravity was accomplished by measuring the volume displacement of 1 gram of material in benzyl ether.

Oxygen utilization varied from "not measurable" at 11.2 percent moisture to a maximum of 0.756 mg/g/hr at 60.4 percent moisture content. The value at 30 percent H_2O was very low (0.015 mg/g/hr), and at 70 percent it was 0.712 mg/g/hr. The values for finished compost were about 1/7 of those for compost under active decomposition. A moisture content under 20 percent in finished compost should permit little or no oxygen utilization during storage or shipment.

Vol. 2, No. 3, Autumn 1961--"What is necessary for composting success?" D. F. Rees.

Composting of municipal wastes can be both a means of waste disposal and a means of producing useful organic manure. In many cases, however, there has been no coordination between the disposal and the agricultural requirements. Cities cannot afford to consider the national aspects of composting but must look only at the economics and convenience of municipal composting.

The author thinks that the value of the compost has been overstated in the U. S. and that plants that have shut down have done so because of inability to sell an overpriced material. Compost is similar to good farmyard manure and should be sold at or below comparative prices. As garbage disposal is a municipal service and responsibility, economics should be based on a reasonably low selling price to insure sales of all compost, not selling part at a high price. Until the market is established, total output may not be sold for a year or two. Flexible operation of the plant is very important and it must have good management.

"Refuse separation and composting in Edinburgh." J. Scott.

Three incinerators, built in 1893, 1938, and 1939, were used to treat the refuse of Edinburgh. The latter two included separation and salvage plants. In 1953, a fourth plant was needed and, considering costs, air pollution, agricultural needs, and subsequent sludge treatment, the city decided on composting. A 20-ton/day pilot plant was completed in 1955 employing the Dano biostabilizer system. The high dust and cinder content from ashes necessitated pre-screening so that the tailings were composted for 5 days and then further screened to remove undecomposable material. Two percent ammoniacal liquor was added at a rate of 80 gal/ton as sludge was not available. A market readily developed for compost at $4.90/T in bulk at the plant or $5.60/T delivered.

Contracts were then let for two 140 T/day Dano plants to replace two incinerators. One plant has pre-screening, salvage, two biostabilizers and final screening. The plant showed a savings over separation and incineration of $0.50/T; based on a new incinerator plant design, the savings would be about $1.26/T. Only 42-47 percent of the refuse remains for composting after separation of dust, cinders, stones, glass, and metals. After composting 22 percent of initial weight is rejected and 25 percent remains. Incineration is similar as 21 percent clinkers remain. Pathogens are believed entirely destroyed even though the temperatures are only 45-55° C. Glass is estimated at 6.7 percent. Glass is best sorted out initially and then screened out after composting with vibrating screens.

The city sold compost readily from the small plant but, with the completion of the other two plants and an annual production of 10,000 tons, sales were turned over to a contractor. Selling price is now $2.80/T at the plant to the contractor. The author is well satisfied with the composting process as a sound, practicable disposal plant which ideally should combine domestic wastes and sewage sludge. Any authority faced with a refuse disposal and sludge disposal problem should at least investigate the possibilities of composting.

"Processing wood wastes to increase crop yields." W. B. Bollen and D. W. Glennie.

Wood wastes (sawdust, tow, chips, and ground bark) increase aeration and moisture holding capacity, aid in conserving soil nitrogen, add to the humus supply, and improve soil physical conditions. They also make good mulches. Wood wastes are low in nitrogen and have a high C/N ratio. This deficiency may be overcome by:

1. Applying N fertilizer with the raw wastes,
2. Chemically processing raw residues to incorporate at least 2 percent N, or
3. Composting to give a product low in readily decomposable matter and higher in N.

Humus is essential to good tilth and also serves to store N, P, S, and other nutrients rendered slowly available by microbial action. Humus is composed of the more resistant residues of lignins and the proteins of dead bacterial cells which react to form nuclei, absorbing iron, aluminum, and silicon compounds. Humus C/N ratio is commonly near 10. Since wood residues persist in soil, they produce longer lasting mulches and provide more prolonged effects than other organic residues. Adding N to wood wastes prevents nitrogen depletion for the plants. Greenhouse and field studies on crops with the addition of ground wood wastes, with and without added nitrogen, generally showed greater yields when the nitrogen was added to lower the C/N ratio to 50. Treating sawdust with dilute sulfuric acid at a temperature near the charring point reduces hydrolyzable carbohydrates and makes it less readily decomposable, prolonging its action in the soil and lessening the microbial N demand. Other similar processes were described and several examples were given of composting plants for wood wastes in California and Oregon.

6. The Refuse Utilization Plant of the Werdenberg-Liechtenstein Region in Buchs (St. Gallen) by Robert Giger, President, Association for Refuse Utilization, Buchs.

Processing was begun at the combined refuse utilization and incineration plant in Buchs on January 2, 1962, after a construction period of a little more than a year. With the inauguration of this plant, a project was realized which solved the refuse problems of the cities and villages of the principality of Liechtenstein and the district of Werdenberg (Switzerland).

The refuse problems of the upper Rhine valley became very urgent on the Liechtenstein as well as the Swiss side. The entire valley floor of the Rhine basin is considered a ground water area and must be protected according to water protection laws. This situation continuously poses an almost unsolvable question: Where can the ever-increasing amounts of refuse be disposed of?

Requirements of hygiene and aesthetics, besides those of water protection, called for a general nuisance-free solution to the refuse problem.

The intention to solve this problem on a regional basis due to financial considerations brought together the authorities of the communities of Vaduz, Schaan and Buchs for the initial discussion. This resulted in the appointment of a commission of three to study the broad problem and suggest a rational solution. This required study of the various refuse disposal systems, the areas of service, the location of plants, the legal bases, transportation, and the over-all financial problem.

The Commission completed the initial study and compiled a report for the interested authorities. The Commission, trying to create a break-through in refuse utilization, suggested the following: build a refuse grinding plant combined with a sludge mixer using the system of the Bühler Brothers Company, Uzwil, to serve an area with a population of 40,000. Installation of a refuse incinerator and a carcass crematorium should be contiguous to the grinding plant.

The thoughts leading to this recommendation were as follows: The systems of refuse disposal consist of the costly method of incineration and the conversion into compost. Larger cities with a small market for compost more often turn to incineration; in our case, where market possibilities are present for compost, we turned to a composting plant for the solution.

Buchs was selected as the location as there was the possibility of utilizing sludge from the sewage plant.

The capacity of the plant was considered in terms of the radius of operation. The basis was the amount of refuse from 40,000 people. As it was known that hauling of refuse over more than a certain distance (20 km) is not economical, it was decided to limit the area to the communities of the district of Werdenberg and the entire principality of Liechtenstein. Even though the city of Sargans and the upper Toggenburgian villages of Wildhaus, Alt St. Johann, and Stein are now delivering refuse to our plant, it is planned that these communities will later join in a local plant.

The legal basis for the endeavor brought certain difficulties because Liechtenstein as well as Swiss laws had to be observed. The solution was found in the association.

At the first authorities' conference on December 11, 1959, it became clear that the communities in the area were interested in such a plant and so it was decided by the three initiating cities, Vaduz, Schaan, and Buchs, to build the refuse utilization plant.

The signal for the start was then given. The city of Buchs and the principality of Liechtenstein made the first funds available with which the mechanical installation was ordered from Bühler Brothers Company of Uzwil. One member from the city of Schaan was added to the Commission. The Commission was authorized to supervise the detailed planning. This was done until the association was founded. The engineering firm of J. J. Gabathuler in association with the architectural office of W. Gantenbein, both of Buchs, were given this job. Construction began in October 1960. On December 27, 1960, the Association for Refuse Utilization and Carcass Disposal was formed. The

Association took over the project responsibility and financing on January 1, 1961.

Components of the Refuse Utilization Plant, Buchs

Upon entering the receiving area, the refuse is dumped into a large bin without any sorting. An effective exhaust controls the dust in the bin. A specially built, rugged steel plate conveyor transports the refuse directly into a coarse mill. A shutter regulates the feed into the mill.

Everything is coarse ground and then transported by a belt to the magnetic drum from which the ferrous metal is conveyed by belt to a special bin. The iron-free material then falls into a fine mill where glass and other splinters are pulverized. A chain conveyor then brings the ground refuse to a vibrating screen where the refuse is separated into two fractions.

The screen rejects (plastics, cloth, rubber, etc.), are transported by another chain conveyor directly to the incinerator room. One furnace serves for burning the screen reject together with non-compostable items, used oil, etc. Another furnace is equipped for burning animal carcasses and butcher offal. The ash is transported out by a special chain conveyor.

Screened material suitable for composting falls over a measuring device into a double-cam mixer. Here the material is mixed with automatically regulated amounts of well-digested liquid sludge. The dust collected by the exhaust system is also added and the mixture is then transported to the composting field.

The need for employees is minimal. The entire processing plant is automatically controlled through a central electrical control board.

The ground material containing sewage sludge is converted in about 3 - 4 months by aerobic decomposition, with the addition of oxygen through turning, into a valuable soil-improvement material. The demand for this material is steadily increasing in vineyards, truck farms and forestry.

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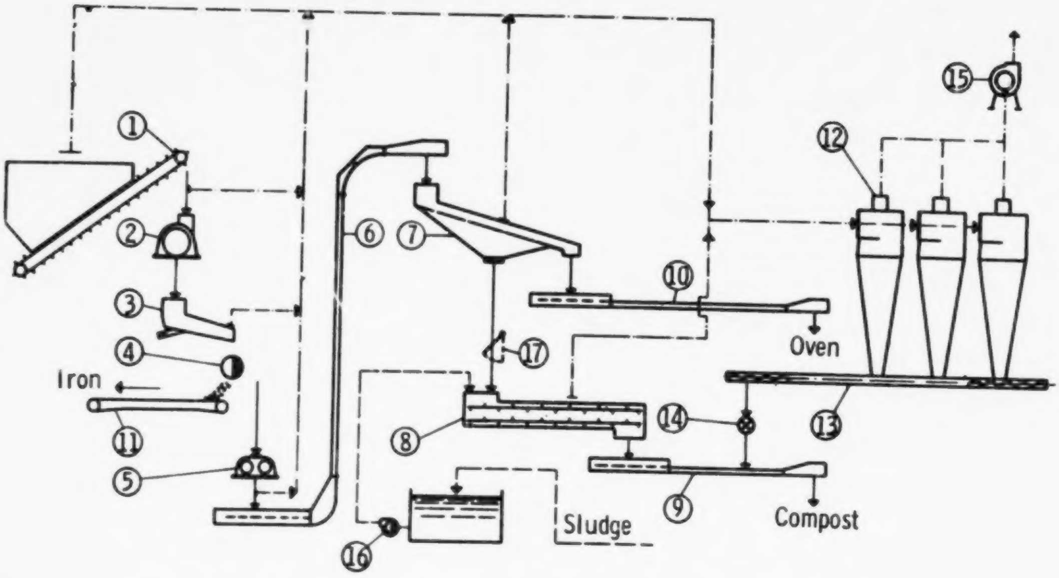
Essentials of the Refuse Processing Plant of the Werdenberg - Liechtenstein Region


①
②
③
④
Iron
⑪
⑤
⑥
⑦
⑩
Oven
⑰
⑧
⑭
⑬
⑨
Compost
⑯
Sludge
⑫
⑮

Legend

1. Plate conveyor
2. Hammermill
3. Measuring device
4. Magnetic drum
5. Fine mill
6. Chain conveyor
7. Vibrating screen
8. Double-cam mixer
9. Chain conveyor
10. Chain conveyor
11. Belt conveyor
12. Cyclone
13. Dust collecting screw
14. Sluice
15. Blower
16. Sludge pump
17. Shutter control

The capacity of the mill is about 15 m^3/hr or about 4T/hr.

The bulky material, which is collected monthly, is not passed through the grinding plant nor is the industrial refuse that is not suitable for composting. After the sorting of scrap iron and combustible material, the scrap iron is delivered to a junk dealer and the combustible material is conveyed to the incinerator.

The incinerator plant contains two furnaces with a capacity of 400 kg/hr in the refuse furnace and 200 kg/hr in the carcass furnace. It was constructed by the Rudolf Würgler Company of Arbon. Auxiliary heat is supplied by oil burners. Charging of the furnaces can be from the top for smaller pieces (screen rejects, butchers' offal) or from the side through a large opening. The furnaces are electrically controlled. The relatively small amount of ash from the furnaces is mixed in with the compost.

After operating our refuse plant in Buchs for over half a year, it became clear that our original calculations were realistic. This was especially true for the domestic refuse but the industrial wastes and bulky materials were delivered in much larger amounts than were estimated. This will require that physical and organizational changes be made sooner than planned. It is anticipated that part of the finished compost will be screened and bagged.

7. Refuse Compost--A Product of the Werdenberg-Liechtenstein Cooperative Plant by Agr. Engr. Ernst Ospelt, Agricultural Consulting Service, Vaduz.

Construction of the cooperative plant in Buchs was planned, among other things, with the thought that refuse could be converted into a product which can be returned to nature as humus. The alternate method of incineration could have been selected. The question of restoring improved conditions to our soil which is in constant demand for humus, which is also scarce in our region, appears to be the correct approach.

At first it may not seem logical for one reason or another that it is possible to change this conglomeration of all possible materials into something useful. An inspection of the receiving bins and then of the windrows of finished compost should be more convincing than many words.

The process has already been described elsewhere so I will limit myself to the possibilities of utilization. We must first take up the definition of the term "refuse compost." There are plants which process refuse without any additions. The plant in Buchs is fortunate that it is able to obtain sufficient sludge from a nearby sewage treatment plant to mix with the refuse. This provides a definite improvement in the end product over the usual compost.

Refuse-sludge compost is comparable to very good stable manure in regard to content and effect.

The Area of utilization of compost is very large. Continued farming, gardening, orchardry, winegrowing, and forestry in the long run are unthinkable without sufficient addition of humus. In addition to the regular nutrients, the soil demands a sufficient supply of humus which must be added at regular intervals. Stable manure, previously used for this purpose, is becoming increasingly scarce and the refuse compost is therefore a welcome substitute. The garden industry uses it in a raw state as a warm bed covering and the finished compost is used in all phases of cultivation. In our ornamental gardens finished compost is added to the flower beds and has an excellent effect as a source of humus on the lawns. Its application is practical and it may be applied at all times. One of the greatest advantages, compared to other humus fertilizers, is in its freedom from weed seeds and potential pathogenic organisms.

One large area of use for compost is in the vineyards. Our vineyards are intensively cultivated with repetitive soil tillage and a heavy drain on humus. The addition of 2 m^3/are of compost every two years provides the necessary humus in sufficient quantity and best quality. As a rule vineyards are planted on more or less steep slopes. As a result the yearly erosion floods wash away the finest soil particles. These amounts of compost addition have been shown in many experiments to hold the erosion of fine soil to a minimum.

Operation of a forestry nursery is unthinkable without the addition of humus. The rapid turnover in these installations consumes huge amounts of humus. Refuse-sludge compost, mixed with leaves, pine needles, and peat, provides a product in the shortest time which is very suitable for forest nurseries.

As shown, the application areas for our compost are very diverse, proving that the right path was taken with the construction of a compost plant. Markets are also available as there are large truck farms and a great many home and ornamental gardens in the Werdenberg area and in Leichtenstein. Vineyards continually total around 30 hectares. The price of compost is very favorable. Compost is superior to stable manure with the same content and compares favorably to other humus fertilizers. The conclusion to return organic matter to the soil instead of destroying it was proper because there is still sufficient exhaustion of the soil being carried out.

In this respect the cooperative plant of Werdenberg-Liechtenstein fulfills a double purpose. For one, it makes possible the sanitary disposal of residential and industrial refuse so that ugly dumping grounds can be eliminated. On the other hand, a product is obtained from seemingly useless material which is used as a soil-improvement material and source of humus for the many varied phases of agriculture providing a valuable service.

8. Contribution to the Investigation of Soil Biology by Prof. Dr. J. Keilling, Director, National Institute of Agronomy, Paris, with the assistance of Messrs. A. Camus, G. Sarignac, Ph. Dauchez, M. Boitel, and Planet (from a lecture and discussion held June 15, 1960 at the Académie d'Agriculture, France).

Ed. Hofmann published in 1956 a comprehensive paper giving results of his investigations on: The Enzyme Level of the Soil. The author and his co-workers were able to prove the existence of a great number of enzymes in the soil. These enzymes represent a picture of the soil and show the succession of activity by the developing microbial flora.

In connection with work on the changes of organic fertilizer in the soil and to compare various soils, we developed, since 1959, a method to determine basic phosphatase in soils and organic fertilizers. After a year of continuous work and about 1000 measurements, we believe it is appropriate to report our results.

A. Basic Phosphatase in Organic Fertilizers.

Besides natural fertilizers (manure) decomposed organic products are on the market which are obtained from greatly varied raw materials and which have very different microbial populations. Their contents of basic phosphatase and total nitrogen are given in Table 1.

Table 1

Humus Fertilizer

No.	Phosphatase Index Per gram dry wt.	Microbial Population Per gram dry wt.	% Carbon dry wt.	% Nitrogen dry wt.	C/N
1	10,855	4,244x10^6	7.6	1.8	4.2
2	7,163	1,079 "	12.4	1.7	7.3
3	7,142	407 "	39.5	1.4	28.2
4	5,151	949 "	39.1	1.1	35.3
5	2,053	244 "	11.5	1.5	7.7
6	1,324	607 "	2.8	2.1	1.3
7	545	30 "	9.0	0.4	20.9
8	393	91 "	16.6	4.6	3.6

As can be seen there is no relationship between the nitrogen content and the enzyme activity or the number of microorganisms.

B. Basic Phosphatase in Soils.

The surface layers of cultivated soils gave a wide range of values, that is between 70 and 1200, depending on the particular test. The values for African soils fell in general under similar French results. The values from parcels of certain farms yielded strong grouping (Table 2).

Table 2

Results from Farms in Saint-Pierre-Aigle,
par Coeuvres (Aisne)

No.	Phosphatase	Nitrogen	Carbon
1	256	0.085	0.89
2	212	0.073	0.74
3	176	0.060	0.74
4	152	0.054	0.74
5	240	0.071	0.86
6	276	0.077	0.86
7	412	0.11	1.18

The examination of deeper (soil) layers gave interesting results and a strong deviation of results from different localities (Tables 3a-c).

Table 3a

Soil Probes at Various Depths, Lands of de Lessay (Manche),
Uncultivated Land

Depth	Phosphatase	Nitrogen	Carbon
Probe No. 1:			
0-10 cm	860	0.50	8.3
10-20 cm	564	0.37	6
20-30 cm	120	0.15	2.95
30-40 cm	52	0.10	1.77
40-50 cm	8	0.07	0.48
50-60 cm	0	0.08	0.33
60-70 cm	20	0.06	0.22
Probe No. 2:			
0-10 cm	204	0.34	6.91
10-20 cm	56	0.18	2.65
20-30 cm	36 *	0.12	1.62
30-40 cm	28	0.07	0.72
40-50 cm	12	0.03	0.03
50-60 cm	24	0.03	0.03
60-70 cm	0	0.03	0.14

* Given as 336 in the French version (Ed. note).

Table 3 b

Soil Probes at Various Depths, Terres de Champagne (Marne), Newly Cultivated Land, Chalk-Containing Soil

Depth	Phosphatase	Nitrogen	Carbon
Probe No. 1:			
0-10 cm	728	0.21	2.03
10-20 cm	708	0.20	1.89
20-30 cm	300	0.12	0.14
Probe No. 2:			
0-10 cm	1,076	0.23	2.29
10-20 cm	972	0.23	2.24
20-30 cm	360	0.09	0.73
Probe No. 101:*			
0-10 cm	632	0.18	1.35
10-20 cm	692	0.19	1.43
20-30 cm	292	0.12	1.24
Probe No. 102:*			
0-10 cm	844	0.18	1.84
10-20 cm	1,044	0.23	2.47
20-30 cm	272	0.12	0.79

* Not included in the German version (Ed. note).

Table 3 c

Soil Probes at Various Depths, at Sols de Creances (Manche),

Depth in cm	Photphatase		
	Fertilized	Not Fertilized	Not Fertilized*
0-10	100	120	832
10-20	92	36	712
20-30	236	36	292
30-40	540	20	188
40-50	56	8	84

* Not included in the German version (Ed. note).

Although it may seem early to try to derive valid conclusions from the results obtained, at least the existence of an "enzyme stock" in the soil can be considered proven. It is now possible to determine after more experimentation a threshold point below which one would find the stock to be disappearing and above which it would be possible to make maximum use without restoration (with manures).

Establishment of such threshold values, each according to climate, agricultural classification and soil types, could without doubt lead to a better foundation for rational methods of soil management. In addition, it will be necessary to determine by further investigation to what extent mineral fertilizers must be used to further, retard, or destroy the enzymatic activity.

Discussion:

Baratte: Could one determine the age of development of enzyme coefficients in certain soils and places?

Keilling: The experiments lasted only one year. Until now no change has been detected. The values remain constant for a year in cultivated soils.

Ferrant: I believe that the principle mentioned by Dr. Keilling is important. It is capable of use to great advantage in tropical soils in which we found great differences that were dependent on climate and not mineral fertilization. The enzymes, as mentioned by our colleages, may be easily destroyed under certain conditions. In tropical climates, such as Senegal, there are extremely dry periods in which basic elements are concentrated. Is this concentration favorable or unfavorable for the formation or maintenance of the enzymes? Many questions are apparent and their answers are of greatest interest.

Dufrenoy: What method was used by Dr. Keilling to measure the phosphatase activity? I have personally found the index of alkaline phosphatase one of the most sensitive reactions for estimation of antibiotic activity. What Dr. Keilling has said could have important effects. Perhaps the problems of microbiological antagonism and of the rhizosphere could be successfully studied by this method.

Keilling: The method is very well known: It is used in cheese and butter control to check whether pasteurization has taken place. It is used also as a control measure in this instance. The problem differs in the soil where the categories of microorganisms and the intensity of microbial growth are important. The reaction used is very classical. A solution of boric acid and barium hydroxide is used for cold extraction of the endogenic and exogenic enzymes.

This extraction takes place in the presence of phenyl phosphate with the liberation of phenol which is measured colorimetrically. A very stable measuring scale can be used to obtain the value. As to what future developments will bring, we must be very cautious: We do not know yet where our method will lead us.

Barbier: Is there any indication as to the amount of phosphatase liberated by microorganisms compared to the plant roots?

Keilling: This question was posed to us at the beginning. We have searched near the roots and have eliminated them by screening. Our results were derived from the microorganisms.

Barbier: Does it involve microorganisms of the rhizosphere which are fed by the roots?

Keilling: We still have to investigate the relationship of the microorganisms to the rhizosphere.

Voisin: I would like to pose two questions and add one remark. The first question concerns the phosphatase: Did you determine a relationship between phosphatase activity and the assimilated magnesium (by chemical determination) in the same soil sample? Second question: You say, very modestly, that this is only introductory work. Why have you chosen the phosphatase? Surely you know that Hoffman built his studies on the saccharase of the soil.

Your work shows how fruitful the study of soil enzymes is and the more dynamic instead of static aspects are revealed. It might interest you to know that English researchers were faced with a similar problem. There are soils in Northern Wales which very frequently appear (to cause) stomach cancer in humans. The English scientists found that these soils are very poor in copper and very rich in zinc. Also, an abnormally high saccharase concentration was measured. The English work points to the importance which your work has. One must hope that you will receive sufficient means to continue these interesting studies.

Keilling: The works of Hoffmann pertain to urease and saccharase; but the measurement can only be done after the addition of certain substances to the soil. When we measure the phosphatase, we use soil which has not been disturbed in any way. This is equivalent to a photograph of the soil condition at the moment of examination. This is not the case with the other method when one changes the decomposition by substrate modification and with it the enzyme status. We are, of course, also interested in saccharase and urease but one must realize that the key to all other questions is found in the phosphatase. It is a turntable of all assimilation, decomposition, and nutrition processes. The phosphatase complexes are found everywhere. If one starts here, one has the possibility of following all processes. Perhaps this is not true in all cases but we shall try it.

Ferrand: I find that selecting phosphatase is very good not only for the reasons you have mentioned but also they play an important role in the activity of phosphates compounds. We know the importance of phosphate. Could a relationship be found between the development and presence of this material and the pH of the soil? This plays an important role in equatorial areas.

Keilling: We are not yet that far. We have completed only one year of work in a laboratory with four associates. I must also mention that we had considerable difficulty in obtaining soil samples. In reply to Mr. Voisin s question about magnesium, copper, and zinc, these will be studied to the extent that funds are available.

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NO. 17

MAY 1963

Ferguson, Brooks & Kelly, translators
John S. Wiley, editor

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1. Experiments to Determine the Degree of Decomposition of Refuse Compost by Its Self-Heating Capability by Dr. G. Niese, Agricultural Microbiology Institute, Justus-Liebig-Universität, Giessen.

The purpose of refuse composting is the decomposition of unstable organic matter and the formation of stable organic and inorganic substances. During the beginning of composting and after turning, self-heating occurs under certain conditions, i.e., the temperature of the composting material rises considerably above that of its surroundings. Braun and Allenspach (2) found that temperatures of a compost windrow did not reach the same high level after the second or third turning as was obtained by raw refuse or partially composted refuse after the first turning. The same observation was made in composting experiments at the Agricultural Microbiology Institute, Giessen, (4).

The self-heating of raw refuse can be easily duplicated under laboratory conditions. The question arose, based on the reduction of heat production in the compost windrow, of whether or not the composting refuse in laboratory experiments would have a lower self-heating capability than that of raw refuse. The influence of continuing decomposition on the self-heating capability was examined under constant conditions in the laboratory to answer this question. Many samples of refuse and refuse compost were available as experimental material. Also studied was the self-heating capability of refuse and sewage sludge mixtures stored under various environmental conditions.

The self-heating experiments were conducted in Dewar flasks which were stored in an incubator. The temperature differential between the flask (contents) and the incubator was automatically minimized. This method was proven successful in previous experiments (6,10) and was usable for the self-heating studies without modification. Experiments were also conducted on the necessity for automatic regulation of temperature differences.

PROCEDURE:

The refuse was first well mixed by hand and moistened if necessary. The amount of water added was predetermined from the absorptive material in the refuse. This material had a wide variation in moisture-holding capacity. The refuse was moistened in such a way that there was no runoff, even under heavy pressure, and no lump formation.

The cylindrical Dewar flasks had a diameter of 8 cm, a height of 21 cm, and a volume of 1000 ml. The flasks were loosely filled with the experimental material. Very voluminous refuse, such as shredded refuse with a high paper content, was lightly pressed into the flasks. The containers were then covered with several layers of cotton wadding which was held together with cellulose tape. Temperatures were measured with a platinum resistance thermometer which had a resistance of 100 ohms at 0°C. Recordings were made by two color pens, calibrated from 0° to 100° C, with a dot frequency of 20 seconds, on an 80 mm wide chart which advanced at a rate of 20 mm/hr.

These self-heating experiments were conducted in a temperature-difference regulator of Heraeus Co., Hanau. In this incubator it was possible to

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practically eliminate heat loss from the Dewar flask. The equipment consisted of a Heraeus BA3 incubator, a Norfa type temperature-difference recorder, and the previously mentioned resistance thermometers. The regulating instrument worked with a Wheatstone bridge in which the null branch was connected to the coil measuring unit of the drop regulator. With the resistance thermometers at equal temperatures (flask temperature = air temperature), there was bridge equilibrium. When a temperature difference appeared (e.g., flask temperature greater than air temperature) the regulating process was activated; that is, the incubator was heated until there was a temperature equilibrium between the two resistance thermometers. The desired temperature differential between flask and air temperature could be set on a nominal value indicator. Temperature differences of 0.5° to 2.0°C were adhered to during the experiments. The incubator was built to hold only one Dewar flask.

The experiments reported here were made in a similar apparatus which permitted the simultaneous use of six Dewar flasks. This equipment was also provided by the Hereaus Company and contained: six Hereaus FB 420 incubators with air circulation; six regulators; two, six color pen recorders, calibrated from 10° to 90°C with a dot frequency of 20 seconds; and a 120 mm wide chart with a paper advance rate of 20 mm per hour. The measurement and regulation of temperatures was done with dual-resistance thermometers, 100 ohms at 0°C, of corrosionproof and moistureproof material. The switching, regulating, and recording instruments were mounted on a switchboard. The apparatus functioned automatically; that is, the temperature difference set at the beginning of the experiment remained constant throughout the entire rise in temperature.

MICROORGANISM COUNTS:

Counting of microorganisms was done according to the Koch plate method with incubation temperatures of 25° and 55°C. Fifty grams of refuse, or refuse compost, were mixed with 450 ml of tapwater and shaken for 20 minutes. Further dilutions were made from this solution in the usual manner. A yeast and meat extract agar served as nutrient and had the following composition: 2.0 g Na_2HPO_4 (according to Sörensen); 3.0 g NaCl; 10.0 g Liebig's meat extract; 5.0 g peptone (Witte); 1.0 g Difco yeast extract; 15.0 g agar; and 1000 ml tapwater.

EXPERIMENTAL RESULTS:

I. Heat Loss in Self-Heating

Even with the use of Dewar flasks, heat loss is not preventable in the self-heating of small amounts of organic matter. Miehe (5) pointed out that maximum temperatures of self-heating in laboratory experiments are influenced by the heat losses of the experimental containers. When the material was kept in Dewar flasks without additional heat shielding, temperatures rose to 45° - 48°C in 96 hours. In an adiabatic apparatus (Norman, Richards and Carlyle (7)) the same material rose to 70° - 73°C in 40 hours or less. Bowes (1), Sallans and co-workers (9), Rothbaum (8), Walker and Williamson (11), and others, used apparatus which minimized heat losses in their experiments on self-heating.

The relationship between measured temperatures and heat losses was determined in our experiments. Ground raw refuse heated itself to maxima of 73.5°, 73.6° and 73.5°C when the outer temperature was regulated according to flask temperature. With air temperatures of 25° - 28°C, the same material only heated to 47.3°, 47.9° and 44.5°C. Figure 1 shows the temperature variations of this experiment.

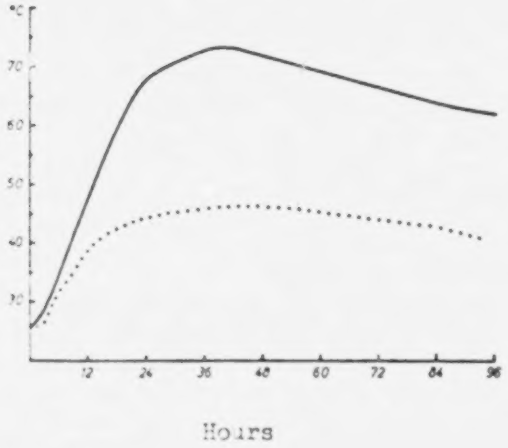


Figure 1. Self Heating of Raw Ground Refuse

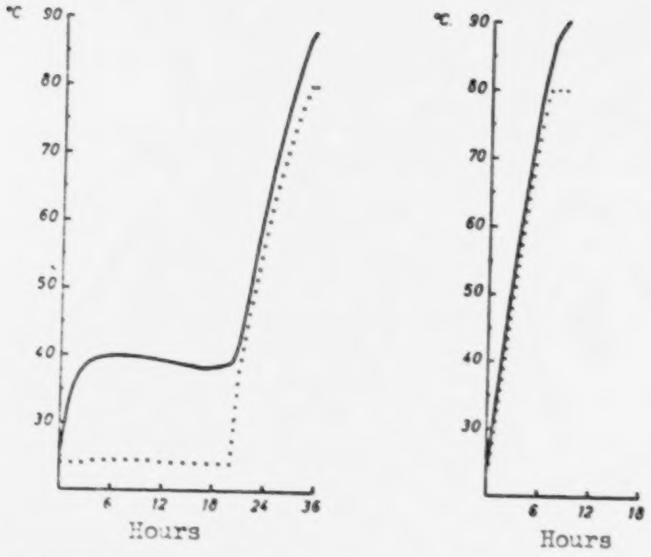
---- Container temperature I; Ambient temp. followed container temp.

.... Container temperature II; Ambient temp. 25 - 28°C.

Differences in self-heating were noted even with refuse from composting experiments due to varying ambient temperatures. Temperatures of refuse compost samples increased to 44.7° and 49.0°C when the automatic temperature regulating unit was used. Material from the same samples heated only to 28.7° and 29.5°C respectively, at a constant ambient temperature of 25°C.

The effect of the temperature difference control was shown very effectively in three model experiments using a constant heat source. A four volt incandescent lamp was installed in the bottom of a 1000 ml Dewar flask to serve as a heat source. The flask was stoppered with a cork covered with aluminum foil. The resistance thermometers were inserted through the stopper into the container with their measuring coils placed in the center of the flask. Direct conduction of radiated heat was prevented by a layer of cotton and aluminum foil between the bulb and the thermometer.

Figure 2 shows that the temperature rose rapidly to 40°C. The outer temperature was initially 24° - 24.5°C. At 38.5° - 40.0°C flask temperature, an equilibrium was reached between heat gain and heat loss. Immediately after the temperature control was turned on, the flask temperature rose and thereby the incubator temperature was increased close to that of the flask. In a further experiment (Figure 3), the lamp and temperature differential control were used from the start. The temperature in the Dewar flask increased steadily to 90°C within 9 hours.



Figures 2 and 3. Temperature Curves With Constant Heat Source

---- Container temperature

.... Ambient temperature

In Figure 4, a varying temperature curve is shown. The temperature in the Dewar flask increased with temperature regulation control up to 90°C. The outer temperature reached 80°C and remained there since this was the upper limit of this particular incubator. The flask temperature dropped to about 68°C as the incubator temperature was dropped to 55°C. The flask temperature again increased with another rise in incubator temperature. As the incubator temperature remained for a long time at 80°C, the flask temperature reached 92°C. After the incubator was switched off, the flask temperature fell to 40.3°C.

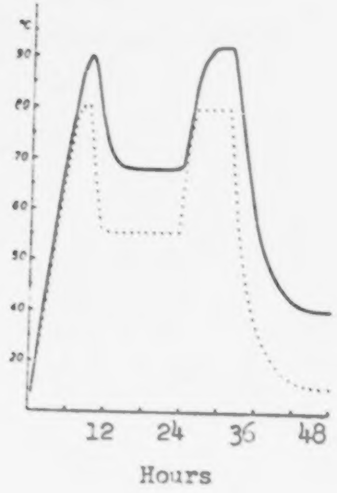


Figure 4. Temperature Curve With Constant Heat Source

---- Container temperature

.... Ambient temperature

These experiments conclusively show that external temperature influences self-heating. If there is a large temperature difference between the sample and the surrounding air, there is not only a reduction in maximum temperature, but also a different temperature curve is obtained.

II. Self-Heating Capability of Various Refuse and Refuse Compost Samples

The self-heating capability of numerous refuse samples was examined. The materials came from laboratory or composting experiments. The purpose of the study was to determine the influence of decomposition, while composting or storing refuse at constant temperatures, on the self-heating capability.

A. Storage of Refuse in a Laboratory Experiment at 38°C and 70°C. In this experiment, refuse-sludge mixtures were stored up to 4 weeks in an incubator at 38° or 70°C. In the trials with 70°C storage temperature, there was a self-heating of the experimental material noted before storage.

1. Storage at 38°C.

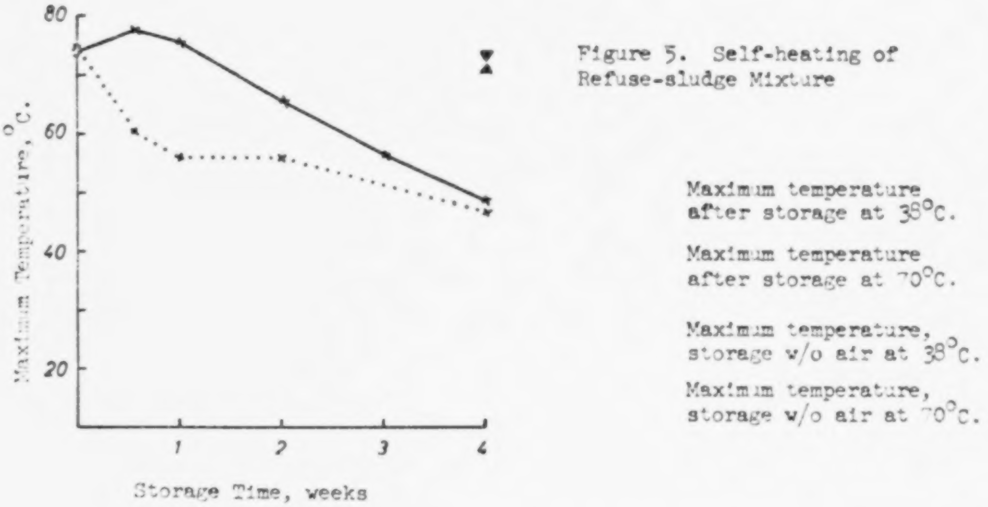


Figure 5. Self-heating of Refuse-sludge Mixture

Figure 5 shows that a maximum temperature of 77.5°C was attained after 4 days of storage. With continued storage, the maximum temperatures of self-heating gradually decreased. Material stored for 4 weeks at 38°C reached a maximum temperature of only 48°C. Refuse to which bacterial nutrients such as peptone, pectin and glucose were added, reached a temperature of 65.6°C after 4 weeks of storage. The same refuse which had been stored at 38°C for 4 weeks, but in the absence of air, reached a maximum temperature of 72°C.

2. Storage at 70°C.

After 4 days of storage at 70°C, a decrease in self-heating could be noticed (See Figure 5). The maximum temperature then was 60.1°C. After longer storage, there was a marked decrease in maximum temperature. After 4 weeks, a maximum temperature of 46.8°C was recorded. In a second trial a refuse-sludge mixture reached a temperature of 46.6°C after 4 weeks of storage at 70°C. This temperature was approximately equal to the maximum temperature of 4-week storage at 38°C. Refuse, stored 4 weeks without air at 70°C, reached a maximum temperature of 73.8°C.

B. Self-Heating Capability of Refuse and Refuse Compost Samples from Composting Experiments. Samples were obtained from a composting experiment in which self-heating could be examined after composting for 4, 7, 17, and 20 weeks. The maximum temperatures in this experiment can be seen in Figure 6. It was also noted in this experiment that the maximum temperatures decreased from 75.3°C in the raw material down to 50.0°C for the material that had composted for 20 weeks.

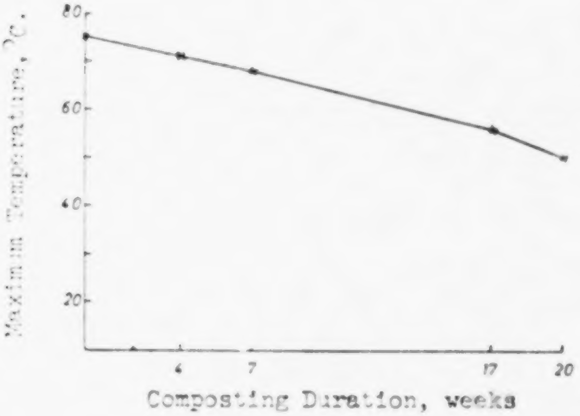


Figure 6. Self-heating Capability of Refuse

Mixtures of aged refuse, sludge and raw ground refuse were available for further experiments. These mixtures had the following composition:

"A" Aged refuse 25%, thickened sludge 25%, raw ground refuse 50%.

"B" Aged refuse 16.7%, thickened sludge 16.7%, raw ground refuse 66.6%.

Self-heating was exactly the same for both samples as shown in Figure 7. The non-composted mixtures reached temperatures of 73.5°C and 74.0°C.

The maximum temperature of the self-heating after 7 weeks of composting was 46.2°C (Figure 8). These samples were obtained from aerobic zones of compost windrows. Immediately beneath these zones were some extremely anaerobic zones. Samples were also taken from these zones and examined. They still showed a strong self-heating capability. The anaerobic material still reached a temperature of 65.8°C after 7 weeks of composting.

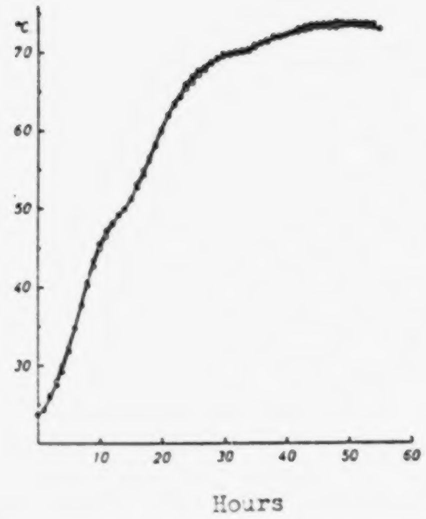


Figure 7. Self-heating of Refuse Mixtures

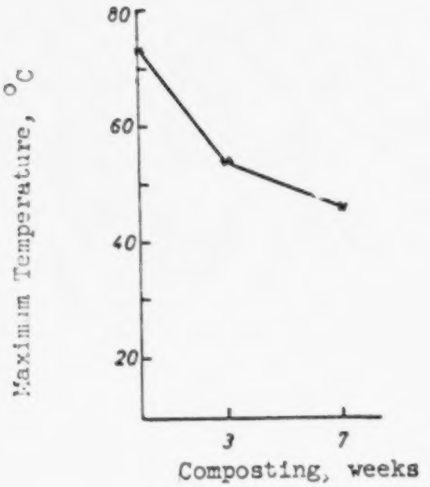


Figure 8. Self-heating of Refuse

Some self-heating experiments were conducted with Dano refuse compost. Three samples were examined:

"A" Refuse after 6-7 days of decomposition in the drum without any windrow composting. Winter refuse, end of February 1962.

"B" Refuse after 6-7 days of decomposition in the drum and 5 weeks additional decomposition in windrow. Winter refuse, middle of January 1962.

"C" Refuse compost after 6-7 days of decomposition in the drum and 1/2 year additional composting in windrow. Summer refuse, September 1961.

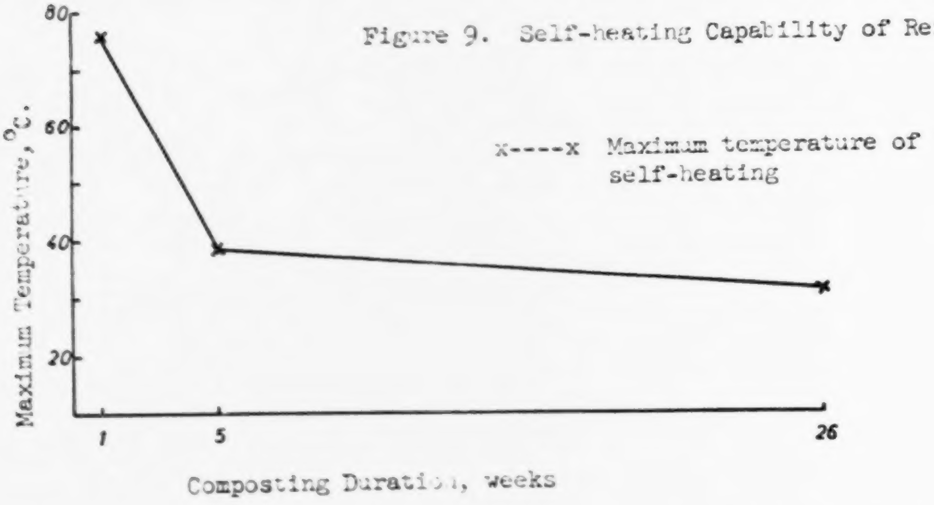


Figure 9. Self-heating Capability of Refuse

The maximum temperatures of self-heating are shown in Figure 9. Refuse examined immediately after leaving the drum reached a temperature of 75.8°C within 47 hours. There was no difference in the temperature curve of this material and of the raw, non-decomposed refuse. After five additional weeks of decomposition in a windrow, there was a maximum temperature of 38.8°C reached in 114 hours. After a 6-month decomposition, there was only minor reheating to a maximum of 31.5°C.

The results of self-heating experiments with refuse and refuse compost from windrow composting were equivalent to the results obtained from spontaneous heating experiments conducted in the laboratory. The maximum temperatures of self-heating decreased with increased storage at constant temperatures, as well as with increased composting duration. The self-heating capability of refuse stored for 4 weeks in the open air was increased considerably with the addition of peptone, pectin, and glucose. This proved that self-heating ability is increased by readily decomposable organic substances which are present in the refuse. The decrease in self-heating ability, occurring after windrow composting or storage at constant temperature, can be related to a reduction in readily-decomposable materials. Reduction of these materials causes decreased growth of microorganisms in the self-heating experiment. The result was necessarily reduced heat production.

Examination of refuse samples, which were stored without air or taken from anaerobic zones of composting windrows, showed much higher temperatures than from the same material stored in open-air containers or taken from aerobic zones of the compost windrows. This difference is explained by the fact that decomposition of organic material is greatly restricted under anaerobic conditions and, consequently, more readily-decomposable materials exist than with aerobic decomposition. The higher content of easily decomposable matter permits more intensive microbial activity which in turn results in greater heat production and, with it, higher maximum temperatures.

III. Microbial Counts and Self-Heating Capability

Results of 10 experiments with raw refuse-sludge mixtures are presented in Table 1. With two exceptions, counts of mesophilic bacteria were between 2,087 and 14,981 million/gm of dry substance. Self-heating started very rapidly in these experiments; 7-15 hours were required to reach a temperature of 45°C.

TABLE 1

Microbial Count and Self-Heating of Refuse
(Incubation in yeast and meat extract agar at 25°c.)

Experiment No.	Material	Bacterial Count (10^6/gm dry wt.)	Starting Temp. °C	Duration of Self-Heating, Hours		Maximum Temp. °C
				To Reach 30°C	From 30°C to 45°C	
20	Raw Refuse	8,149	21.8	6	9	74.0
21	" "	14,981	27.0	3	8	74.8
26/I	" "	3,138	24.6	3	8	74.2
27/I	" "	7,150	24.5	4	10	75.6
BB 1/1	" "	13,304	23.5	4	7	75.3
30	" "	7,420	27.5	1	8	77.5
31/I	" "	2,199	25.0	7	8	74.0
35/I	" "	127.9	23.8	4	6	73.5
35/II	" "	377.98	23.5	4	6	74.0
38/I	" "	13,646	28.3	1/2-3/4	7	74.4
32/I	Composted 3 wks.	1,518	25.3	4	6	74.4
32/II	" "	2,095	24.8	4	8	73.5
32/III	" "	2,087	25.8	4	12	73.8

In other samples, the count of mesophilic bacteria was very low, as shown in Table 2. In contrast to the samples with high counts, there was considerable delay in temperature rise; 96-449 hours were required to reach 45°C. Maximum temperatures for samples with both high and low bacterial counts were above 70°C.

TABLE 2

Microbial Counts and Self-Heating of Refuse
(Incubation in yeast and meat extract agar at 25°C.)

Experiment No.	Material	Bacterial Count (10^6/gm dry wt.)	Starting Temp. °C	Duration of Self-Heating, Hours		Maximum Temp. °C
				to reach 30°C	from 30°C to 45°C	
27/III	4 wks. 70°C anaerobic	0.0034	25.8	78	18	73.8
BBI	Composted 4 wks.	0.252	18.5	264	51	71.0
BBII	Composted 4 wks.	0.164	23.5	412	37	73.5
31/VIII	4 wks. 38°C anaerobic	0.04	23.8	6	101	72.0
38/VIII	4 wks. 70°C Anaerobic	0.051	23.0	57	19	70.8

It is undersirable to have slow heating to 30°C or 45°C in the self-heating experiments, as this causes prolonged experiments. For this reason, speeding up of the process was tried by the addition of bacteria. This was done as follows: Petri dishes containing yeast and meat extract agar were inoculated with a raw refuse-sludge solution and incubated for 4 days at 25°C or for 2 days at 55°C. The resulting bacterial growth was then converted into an inoculent by repeated washing and centrifugal separation in Ringer solution. This inoculant was then added to the low-bacteria experimental material. Through this it was possible to increase the bacterial count and to reduce the period required for the material to reach 30°C by 168 hours (See Table 3).

TABLE 3

Microbial Counts and Self-Heating of Refuse
(Incubation in yeast and meat extract agar at 25°C.)

Experiment No.	Material	Bacterial Count (10^6/gm dry wt.)	Starting Temp. °C	Duration of Self-Heating, Hours		Max. Temp. °C
				To reach 30°C	from 30°C to 40°C	
38/VII	4 wks. 70°C not inoculated	0.123	23.0	248	47	46.8
38/V	4 wks. 70°C inoculated	1,448.3	25.0	80	57	50.7

For temperatures above 30°C there was no improvement noted.

Unquestionably the type of microorganism which is added to the experimental material is very influential to heat production. However, this was not considered in these experiments. If one were to do so, it would require a systematic study of the bacterial flora occurring during composting.

IV. Discussion of Results.

Experiments were conducted to determine the effect of decompostion on the self-heating capability of refuse and refuse compost. Heat losses occurring during laboratory studies of self-heating are of great importance. The microorganism activity in an organic medium results in heat production. Temperatures increase when heat is not dissipated. Depending on the effectiveness of heat storage, maximum temperatures of about 75°C occur. The following conclusions can be made: When high temperatures are expected, such as in the decomposition of refuse-sludge composts, favorable conditions for heat production and retention must be provided. If high temperatures are undersirable, then heat conduction is necessary. The same principles must also be considered in the laboratory self-heating experiments. When it comes to attaining the temperatures rendered possible by the biological formation of heat, the conditions with which one works must compensate for the heat loss by means of a heat reservoir. The results of self-heating experiments, shown in Figures 1 - 4, show conclusively the dependence of temperature increase on ambient temperatures. The maximum temperatures reached with low ambient temperatures were considerably less than those with the same materials in a temperature-regulating device. These results show that temperatures of self-heating, with large temperature differentials between flask temperature and ambient temperature, are not the same as those present during spontaneous self-heating. They are therefore considered unusable in determining the degree of decomposition.

Many experiments were run to examine the self-heating capability of compost material. Results indicated it is possible to determine the degree of decomposition of refuse by laboratory experiments of self-heating. This pertains not only to the experimental material taken from compost windrows, but also to refuse-sludge mixtures which had been stored at various temperatures for up to 4 weeks. It was possible to increase a declining, self-heating capability by the addition of peptone, glucose and pectin; higher maximum temperatures were obtained thereby, than from the same material to which these nutrients were not added. It was thus proved that self-heating capability depends on the nutrients present in the substrate.

It was further shown that the same maximum temperatures were reached with varying experimental durations. The duration of the experiments was especially influenced by delay in the start of the self-heating. If the material had a high bacterial count, the temperature rose immediately; but at low bacterial counts, delays occurred. It was possible to reduce the delays greatly by the addition of bacteria to the material with low counts. These experiments indicated that there is a good probability that the maximum temperature of self-heating depends only on the amount of nutrients available to the microorganisms. The microbial content of a material, therefore, has no effect on the maximum temperature, but does influence the speed of temperature increase. Delays are expressions of regeneration of a numerically low count of microorganisms. These occur particularly under the influence of high temperatures and anaerobic conditions. Regeneration of microorganisms can be started before the experiment if the sample isn't immediately cooled after sampling. It is for this reason that the absence of delays in temperature increase is not proof that there was no damage to the microorganisms during decomposition. A noticeable change in nutrient content, accompanied by a change in maximum temperature, need not be feared even when the material has to be stored or transported for several hours without cooling. The maximum temperature therefore provides a surer guide to the degree of decomposition than the speed of temperature rise.

A judgment of decomposition of refuse and refuse compost samples can be made according to present results:

Maximum Temperature Reached	Degree of Decomposition
Above 70°C	0 Raw refuse, very short or slight decompostion
60-70°C	1 Moderate decomposition
45-60°C	2 Medium decomposition
30-45°C	3 Good decomposition
Under 30°C	4 Decomposition mostly or completely finished

It is obvious that this chart is only an outline. However, it is necessary to establish a basis for determination of degree of decomposition, after which various composts can be classified. The usability of this chart must be determined by further comparative experiments, particularly plant-growth experiments.

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2. Plant-Growing Experiments with Refuse Compost in Japan. A condensation of the work of Professor N. Nakamura, Hyogo Agricultural University, Japan, by Engr. V. Stahlschmidt, Zürich.

Nowhere in the world has the growth of large cities been as rapid as in Japan in the past few years (Tokyo has a population of almost 10 million today). Solutions of the problems of public health, water supply and sewage and refuse disposal, are therefore especially pressing in Japan.

Refuse removal is not only a technical, but also a financial problem. It is therefore obvious why efforts must be made to adapt the most economical process, refuse composting, to Japanese conditions. Various methods have been checked along with determinations of the value and usability of refuse composts.

A composting plant with a daily capacity of 25 tons was built in 1956 at Kobe with the assistance of the World Health Organization (WHO). It was built according to the Earp-Thomas system (prefermentation in a digester). This plant did not perform up to expectations (see Wiley: Composting of Organic Wastes--An Annotated Bibloigraphy, DHEW, PHS, Supp. 1, pp 34-35, June 1959). A biostabilizer plant was built in 1957 in the old Emperor City of Himeji. This system was successfully tested there and experiments were conducted with the compost produced to determine its value for plant growth. Five more plants have been built and seven more have been contracted for in recent years.

The plant-growing experiments were conducted at the Hyogo Agricultural University under the direction of Professor N. Nakamura and included the following:

1) A finished, rather than dried, compost was used with an average moisture content of 30% and containing 0.6% N, 0.38% P, and 0.55% K (dry basis).

2) The amounts of compost applied were 0, 7.5, and 15 tons per hectare.

3) These experiments were repeated three times on plots of 3.3 m^2, each time on two different soils. The first soil had a good humus content and the second had been treated for years with only chemical fertilizers.

4) The following plants were used in the experiments: radishes, lettuce, celery, sugar beets, white cabbage, strawberries and onions.

5) Each experimental plant was fertilized with chemical fertilizers in amounts which had been found to produce the best results. The following are examples of the quantity and type of fertilizers used:

	Radishes	Lettuce	Celery
Kg N/ha	125	190	300
Kg P/ha	100	120	200
Kg K/ha	150	150	210

The total content of N, P and K of the compost was included in the fertilization even though the N and P in the compost was not immediately available to the plants. It might be expected, therefore, that the plants would yield lesser amounts during a short growth period when compost is used.

6) In comparison, 7.5 and 15 tons/ha of manure were also used. It contained 0.5% N, 0.2% P and 0.5% K.

Results and evaluations, which are being continued, of these experiments comprise more than 50 pages, and it is only possible to give a very brief condensation of the results here.

Experiments at Hyogo Agricultural University, 1959.

Plant Yield in Percentage (0 - plot = 100%).

	Compost			Stable Manure	
	0	7.5	15	7.5	15 T/ha
Radishes (1)	100	103	109	98	108
Radishes (2)	100	152	172	155	189
Lettuce	100	107	107	98	109
Celery	100	103	106	91	95
Sugar Beets:					
a) Yield	100	117	111	105	97
b) Sugar in %	100	103	104	102	102
c) Amount of sugar	100	121	115	106	98
d) Total N	100	84	82	96	89
White Cabbage:					
1) 77 days, farm 1	100	94	83	94	73
2) 147 days, farm 2	100	161	210	159	200
Strawberries:					
a) Yield	100	114	120	115	103
b) Sugar in %	100	106	109	106	109
Onions:					
a) Compost spread in rows	100	104	82	89	104
b) Compost broadcast	100	98	105	--	---

pH Value and Humus Content of Soil in the Celery Experiment

	pH	Humus Content %
Start of experiment	7.1	3.03
After experiment, without compost	4.9	2.17
" " , 7.5 T compost	5.8	2.55
" " , 15 T compost	6.7	3.06
" " , 7.5 T stable manure	5.2	2.20
" " , 15 T stable manure	6.2	2.72

Conclusions:

1) The refuse compost proved to be equal or superior to stable manure.

2) The addition of 7.5 T/ha gave a higher yield than that of 15 T/ha. The optimum amount is probably about 10 T/ha.

3) Failure of the first cabbage experiment was probably due to a lack of readily-available nutrients. The second experiment resulted in favorable action of compost on the yield.

4) Compost not only increased the yield and sugar content of sugar beets but also reduced the content of nitrogen. The reduction is favorable for sugar processing.

5) In the onion experiment it was found that a concentrated application of compost (directly in the rows) results easily in an overdose.

6) During the celery experiment it was noted that the pH value of the soil is not increased, but the acid effect of the necessarily high mineral salt additions is neutralized. Maintenance of humus is only possible with compost and an amount of 15 T/ha is sufficient.

These experiments are being continued and results will be published at their conclusion. This preliminary report might serve to stimulate similar experiments.

3. An Approach to Municipal Composting* by John S. Wiley, Solid Wastes Engineering Consultant, U. S. Public Health Service, San Francisco, California.

Composting is on trial in the United States today as a general method of treating community wastes. In the past, primary motivation for compost-plant installations in this country has been profit, and no plants have

*Reprinted from: Compost Science 2(2) 6-7, Summer, 1961.

been built by public agencies or at public expense. More often than not, full-scale plants to compost community wastes built in the last decade have been discontinued.

Each of the five or six currently operating plants in the U. S. is a prototype, and the many responsibilities of proving the process to be feasible, sanitary, and economical rest almost entirely on the company which developed and built the plant. In addition, these companies have had to prepare and sell the compost and salvaged items because such sales accounted for the chief income of the operation. The latter is an imposing task in itself because (a) no national need for the application of compost to improve soil has been demonstrated and (b) no scientific determination has been made to assess the monetary value of compost in terms of soil improvement or increases in plant germination, growth, or yield.

Thus, the tasks imposed on themselves by these private concerns are enormous and some responsibilities may not have been fully understood initially. It is no wonder, then, that a number of composting operations were discontinued, especially when conducted as solitary ventures without adequate research and development in all aspects.

Both water-borne and solid wastes are products of man and his activities. It is a public responsibility to effect their satisfactory collection, treatment, and disposal. The provision of such services is an over-all expense that is justifiably borne by the public. Therefore, the most sanitary, efficient, and economic waste collection and disposal systems should be provided as a public service. Comprehensive, long-range planning of the waste disposal service should be included as a part of over-all community planning. Such plans, as well as their subsequent fulfillment, if not implemented by a public agency, will at least require the knowledge and approval of the health and public works officials concerned.

Storage, collection, and disposal should be intergrated in the case of refuse disposal. The collection service generally represents about two-thirds of the total refuse disposal cost and should be carefully studied in relation to proposed disposal methods. Such alternatives as combined or separate storage and collection, or the use or non-use of refuse transfer stations, are very important in the efficiency and economy of the system. Both current and projected measurements and analyses of wastes, populations, and land uses may be required in planning. The public health and nuisance aspects of the entire system are of primary importance.

When the system of collection and disposal has been established, sound engineering plans and specifications should be prepared to meet the requirements of public works and health officials. Safety, fire, and building construction requirements should be met. Adequate provision must be made for sanitary processing of the wastes in event of equipment breakdowns and outages.

Construction and operation should then proceed in accordance with the plans and to meet requirements relative to health, safety, and freedom from nuisance. Wastes must be processed promptly, and plant cleanliness must be maintained.

FEASIBILITY OF COMPOSTING

Any waste treatment process should be feasible; safe from public health, accident, and nuisance hazards; and economically competitive with other satisfactory treatment methods. Research has shown the technical feasibility of composting U. S. municipal wastes (1-4). Numerous plant installations abroad have shown the practicality of composting refuse or refuse-sludge (5-8). Most of the European plants are publicly owned and operated and, while generally economically competitive with other means of refuse disposal, are nonprofit-making (8).

The degree of decomposition provided in composting may be controlled by regulating the time of active composting and of curing. Any of several composting processes or combination of processes may be used without the creation of nuisances, including fly breeding.

The public health aspects of refuse treatment can be adequately met by composting (9). The compost derived from refuse is generally accepted as being innocuous from a health standpoint (2,5,6,9). It may require further processing for safety, such as by removal of glass and metal particles, if destined for subsequent handling by the public. The compost derived from refuse and sludge has the potential hazard of a residual pathogen content. Proper aerobic thermophilic composting intrinsically produces the time-temperature required for pathogen destruction (1,2,5,6,9,10). With enclosed composting systems having sufficient retention time and the proper environment, all parts of the mass will be exposed to pathogen-killing time-temperature. In open air composting involving sludge, there is danger that outer portions of the mass may not be adequately subjected to thermal kill. Several turnings, each providing good mixing and aerating, are therefore required in open windrow, pile, or pit composting involving sewage sludge or nightsoil (10,11). The complete efficacy of this is still to be proven.

Recent studies (10,12) show there is an added factor of safety regarding pathogen kills; this factor is an antibiotic effect which causes destruction at less than normal thermal kill temperatures. It thus appears that even outdoor methods may produce a safe compost from refuse-sludge, but this should be carefully evaluated by performance studies with indicator organisms or with pathogens or pathogen simulants.

Because pathogens may be present in both digested and raw sludges, it appears unjustifiable to limit refuse-sludge composting to the use of digested sludge. Raw sludge enhances the composting of refuse by providing more nutrients for the process than the use of water or digested sludge (5). Composting with a refuse-raw sludge mixture would add little to the expense of composting refuse but would save an estimated one-fourth to one-half of the over-all sewage treatment plant costs required for normal sludge digestion and air drying or dewatering. With the advent of inexpensive means of concentration (13,14), either raw or digested sludges can be adequately thickened so that all refuse and sludge from the same contributory population may be mixed satisfactorily to result in optimum moisture content for composting. In addition, the composting process destroys viable seeds and plant pathogens that may be present in normal sewage sludges (5).

OPERATING COSTS

Gross composting-plant costs of a number of European installations were reported to be: \$3,400 to \$9,230/ton of refuse (daily rated capacity) for capital costs, and about \$2.50 to \$4.00/ton for operating costs, including amortization(8). An unpublished study by the writer in 1959 revealed the following gross cost estimates for two types of plants in Georgia serving a population of 28,750 and treating all refuse (57.5 tons/day) and raw primary sludge (8,200 gpd at 95% moisture):

Windrow composting: \$5,330/ton of refuse (daily rated capacity) for capital costs, and \$4.54/ton of refuse for operating and amortizing costs.

Mechanical composting: \$13,230/ton of refuse (daily rated capacity) for capital costs and \$6.96/ton of refuse for operating and amortizing costs.

The above costs do not include any returns from salvage or compost sales or any savings in sludge treatment costs. Estimates of the latter may approximate \$10.00/capita in capital costs and \$1.00/capita in operating and amortizing costs in a conventional sewage treatment plant.

The two processes above each provide: Sludge holding and concentration, refuse receiving, sorting, magnetic separation and grinding, mixing, composting, and compost curing and storage. The plants are assumed to be sited within one-half mile of the sewage treatment plant and include the pumping of sludge from sewage to compost plant. No provision is made for final refinement or sale of either salvage or compost.

These comments on the feasibility, public health aspects, and economics of composting presuppose sound planning, construction and operation of the compost works. The process should be one previously tested, if not in full-scale installations elsewhere, at least in a pilot model. As with other community installations for waste disposal, the primary objective should be the provision of a sanitary public service, if not conceived and conducted by public agencies, at least so done with their full cognizance and approval.

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4. Moisture Determination of Refuse with the Geisenheimer Water Pliers

by L. Ziegler, Director, Refuse Disposal District, Baden-Brugg, Switzerland.

The optimum moisture content of fine refuse for composting, commonly reported in percentage, depends on the moisture capacity of the particular refuse. Thus, in one case composting might be done with a 40 percent moisture content and in another it might be done at 55 percent; extreme values are even further apart. Bacterial activity during composting is at a peak when a certain and constant amount of water is made available by the composting material. For this reason refuse must be examined for its moisture capacity in addition to its moisture content. The moisture content must then be changed and adjusted, for example, to 75 percent of the maximum moisture capacity. This value, if found to be best for composting, can then be kept constant regardless of the nature of the refuse.

The moisture-holding capacity of refuse is influenced by the contents of coarse minerals, organic substances, colloids, fine particles, salts, etc. While minerals (sand, stones, etc.) absorb almost no water, the other materials bind more or less large quantities of water and thereby keep it from the bacteria. The amount of bound water must be determined and will vary with the composition. Then a surplus of water must be added to be useful in composting. The two required determinations are too cumbersome for compost plant operation and can be done only in a laboratory. This is the cause for the practice of determining moisture capacity in a hand sample. While this method depends on the judgment of one person, it is better than only a moisture content determination.

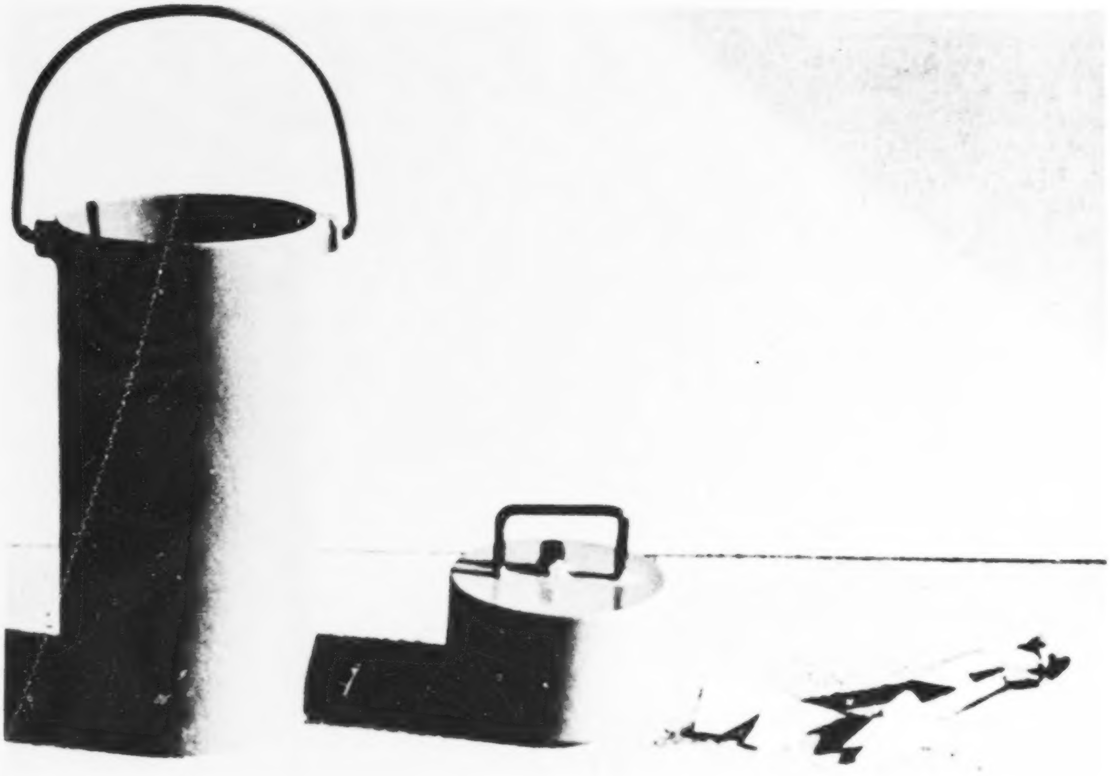
The Geisenheimer water pliers (Wasserzange), built by Dr. Tepe for the determination of free water in soils, can be successfully adapted to serve in refuse composting by adding an auxiliary container. They work with a constant suction and give a relative value based on moisture-holding capacity and moisture content. The optimum value was determined to be 20 mm at 15 minutes. The variations in moisture content in the experiments were 40 to 50 percent.

The apparatus consists of a pair of pliers, the points of which are triangularly shaped and fit exactly upon each other. An activated filter paper is clamped between them, and the excess is torn off to the edges of the pliers. The pliers are then pushed completely into the material to be tested and left there for a certain period (15 minutes in fine refuse). The filter paper becomes moistened inwardly from the edges according to the amount of free water. The width of the filter paper is measured at the point where the two zones meet. [Ed. note: The measurement represents the diameter of a filter paper disc that would be completely moistened.] With too dry a material the value is low, that is a small diameter; and with too moist a material the two zones run together at the top, which gives a large diameter.

The water pliers and filter paper can be obtained from Metall Hartmann in Geisenheim/Rheingau.

Because ground refuse is very heterogneous as compared to soil, an auxiliary apparatus is necessary and can be made separately. A representative sample is well mixed and loosely filled to the top of a round container 200 mm in diameter and 400 mm high. Mixing is important so that the entire sample has approximately the same moisture content. Very different results could be obtained with the same material if the pliers were to contact only paper one time and decomposed vegetable another. It is also important that the material has the same density for each test because more water is liberated under high pressure and very loose refuse will not show the presence of moisture. Thus, a close-fitting 5 kg weight is set on top of the loose refuse. The weight is removed after 5 minutes and the pliers with filter paper are inserted. After 15 minutes the pliers are removed, and the edges of the moisture zones are marked with a pencil and measured as mentioned above.

Despite mixing, it quite often happens that uneven zones occur with fine refuse. It is recommended that measurement be repeated at a different place in the container in such a case.



5. An Inquiry on Ground Preparation for Windrow Areas by Mr. M. Glockner, Director, Transportation, Stuttgart.

Note from the (Swiss) Editor: In Bulletin No. 15, we presented a report by Mr. Glockner on the new refuse composting plant of the City of Stuttgart. As there was much interest in the construction of windrowing areas, particularly regarding surfacing, we asked Mr. Glockner to give us a few detailed facts about the composting area of the Stuttgart plant. We deeply appreciate his response.

The composting area of the refuse composting plant of Stuttgart-Möhringen has an area of 50 x 80 m = 4,000 m^2. It is built lengthwise in the shape of a roof with a 4 percent slope. It was first thought to install pre-cast concrete slabs 2 x 2 m on the compost area. These slabs, reinforced by steel mesh, were to have been laid on a 10 cm porous base, and the cracks were to be sealed with mastic. The cost was calculated to be 41.50 Deutsch marks (DM) per m^2 in 1961. This would have required 166,000 DM, excluding landscaping.

Because of the high cost of the plant due to its geographical location and the expense for the site, we decided to look for a cheaper solution. We then thought of using coarse gravel with asphalt as follows: 5 cm filter layer, 20 cm of coarse gravel with sand filling, 8 cm of rolled gravel, and 35 kg/m^2 of asphalt. This would cost about 25 $DM/m2$ or a total of 100,000 DM. Still another solution was attempted with a simple macadam cover as follows: 5 cm of filter layer, 15 cm of coarse gravel, and 5 cm of rolled gravel including a macadam cover. This cost, including earthwork and auxiliary construction, was calculated at 19 DM/m2 or a total of 76,000 DM which is less than half of the precast concrete cover cost.

We naturally expected to have periodic repairs with the macadam paving and were quite surprised when they were not required. Our powerloader made holes only in the first few weeks, and they were repaired with leftover material. With increasing skill in the use of our front-end loader, the damages disappeared completely. Then something happened which we had expected, fine particles of compost formed an almost concrete-like cover during dry weather, and this protected the macadam paving. This had also occurred at other plants where a similar cover was formed on the natural ground surface. There were no disadvantages experienced due to softening of this cover during rain or melting weather. At these times, the compost area is muddied anyway by the normal usage. Large amounts of mud and dirt can be scraped off by a power shovel. The macadam cover has appreciable drainage capacity so that, to our great surprise, there was very little runoff even in the heaviest rainfall. A pond, especially built to catch runoff water, was not needed at all and was filled in. Also, we did not need a ditch encircling the compost field as originally planned. Only one ditch was needed at the place where the compost area meets the traffic area to the compost works.

The prices discussed above were in effect in 1961; they have probably increased 10 to 15 percent.

In case there is interest in the composting area at Stuttgart, it is possible at any time to have a local tour of the installation.

6. Refuse Analyses by Engr. R. Palm, Basel.

Recent literature contains much about refuse quantities and qualities, heat values, weights, particle size, and moisture. Why?

Do we have information as to the influence that these qualities, such as particles and cinders, have on the incineration of refuse? Is it clearly understood that we can or want to calculate these values?

Do we have the experience here in Europe? I emphasize "here in Europe," where it is well-known that quantities and qualities change very rapidly without our being able to foresee or predict these changes. In contrast to this, American refuse remains practically the same over the years. Can we gain experience from the few plants that are operating?

An incineration plant operator, even after many years, must conclude that he has continuously noted changes. The only experience he has gained is that his is unable to gather any experience.

What good are refuse measurements, operating instructions, construction plans, or even data about costs, efficiency and achievements? These are all momentary values under changing conditions.

We can draw our conclusion from all of them.

We must construct plants which are able to incinerate all reasonable refuse classes. We can then provide final values for the desired data.

It is necessary to know about the combustion processes of the most varied refuse qualities and compositions in order to build incinerators. Various types of observations permit us to compare data with theoretical information so that we can meet the most probable burning requirements even with varying materials. This knowledge serves as a base upon which plans are constructed, operating instructions are formed, and performance and usage limits are evaluated.

It is impossible to escape compromises between heat values, efficiency, performance, and wear.

One precept must always be in effect: refuse incinerators must always be operated hygienically and safely.

We cannot ask ourselves what are the suggested methods which give very accurate results? Is it permissible to make large expenditures based on these methods?

In other places recommendations have been made for procuring sufficiently accurate data and the influences that the quality of refuse generally has upon incineration are discussed.

7. Information from the Secretary

IRGR Work-Group in Israel: A Work-Group of the IRGR has been formed in Jerusalem under the direction of Mr. L. Watson of the Health Department of Israel. The committee is called "The Inter-Ministerial Committee for Utilization of Urban Refuse." We are pleased about the active interest in Israel in our research group, and we hope to have fruitful association together.

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NO. 18

AUGUST 1963

Ferguson, Brooks & Kelly, translators
John S. Wiley, editor

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGR)
Information Bulletin No. 18

1. Some Specialized Equipment Used in European Compost Systems by John S. Wiley, Sanitary Engineer Director Public Health Service.

The wide variety of equipment for processing refuse and compost was very impressive to the writer as seen on visiting a number of composting plants in Europe during 1959 (1). Some of the items of equipment were specially designed for the processing of refuse and have not yet appeared in the United States. Examples are the rasping machine, the secator and the ballistic separator. Other units are conventional or adapted models used in industry, such as grinders, screens, roller crushers, and some types of inertial separators. This discussion presents brief descriptions of a few equipment items in European use for the preparation of refuse for composting or for refinement of the compost for later use. Composting processes, with the many types of composters or "digesters," are not included as they are generally described in articles relating to the particular composting system.

The process steps used in Europe to prepare refuse for composting vary from none to one or more of the following: screening, hand sorting, magnetic separation, grinding, pulverization, and inertial separation. Similarly, processes for refinement of compost vary from none to: screening, grinding, magnetic separation, and inertial separation. In a few plants the compost is bagged. Whether the processing is before or after composting depends largely on the composting system used. The degree of processing depends on the quality of refuse, plans for salvage, particle-size requirements of the composting method, and quality and particle-size specifications for the finished compost.

Refuse processing requirements in Europe differ from those in the United States because the constituent quantities of refuse differ. In Europe, refuse in general has a much higher content of ashes and lower content of paper products, glass, cans and plastics than U. S. refuse. For example, the content of ashes and cinders is rarely less than 25% by weight in summer, and is usually greater than 50% in winter. As a result, the first step in some plants is screening to remove ashes and small cinders, whereas this step may not be desirable at many places in the United States.

SCREENING

Two types of screens were observed for the separation of the finer particles from raw refuse: vibrating screens and rotary drum screens. The same types of screens may be used to refine compost by removing coarse particles from it. Screens for raw refuse separation usually were provided with both coarse and fine mesh or perforations.

Rotary Screen: The rotary drum screen (Figure 1) is housed to prevent dissemination of dust. The drum slopes slightly from inlet to outlet and, where dual screening is provided, the section nearest the inlet is provided with fine

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perforations (about 3/8 inch) and that nearest the outlet, with coarse perforations (1 to 1-1/2 inches). Separate hoppers beneath each section receive the screenings and discharge them to trucks or conveyer belts below. At the Jersey plant, (Jersey, Channel Islands, England), the fine dust and ashes were removed to storage bunkers and later fed back uniformly into the flow of ground refuse to help in absorbing moisture from sewage sludge; the coarser cinders were used as fill. Relatively few rotary drum screens are in use at composting plants.

Vibrating Screen: Vibrating screens (Figure 2) may be of either single or double deck types. Usually single deck screens are provided with uniform perforations throughout the length but they may have sections with two sizes of holes. A double deck unit has coarse perforations (1 to 1-1/2 inches) in the upper screen and finer ones (1/4 to 1/2 inch) in the lower. Decks are inclined downward from the receiving end to the discharge end so that the tailings bounce along to the outlet end. In twin deck screens, the lower deck is longer than the upper. If dust is a problem, these screens may require hoods and dust collection equipment. Vibrating screens are commonly employed in European composting plants. Scott (2) reported a preference for them over rotary screens after trials of both at Edinburgh.

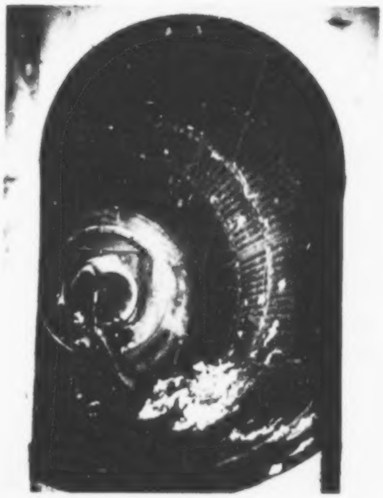

Figure 1. The rotary drum screen at Baden-Baden, Germany.

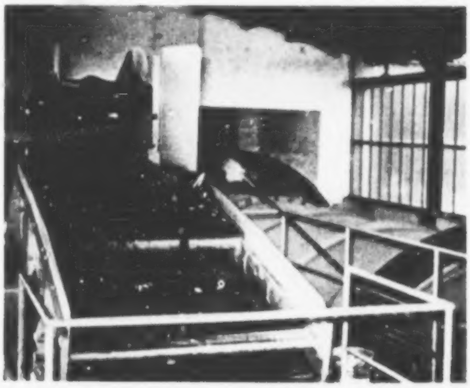

Figure 2. The double deck vibrating screen at Chur (Coire), Switzerland.

GRINDING

The grinding of raw refuse is usually preceded by hand sorting and magnetic separation. Two types of grinders are used in Europe: hammermills and rasping machines.

Hammermill: Hammermills (Figure 3) are usually of the swing-hammer, high-speed type with horizontal axis. More recently, several makes of double-rotor hammermills have been developed in which the two opposing rotors turn at different speeds (3, 4, 5) (not illustrated). Because of the tough and abrasive nature of refuse constituents, high-speed hammermills require relatively large motors and frequent rebuilding or replacement of the hammers and wear plates. At some plants, grinding is accomplished in two hammermills, the first being a coarse grinder and the second producing a finer particle size. Hammermilling of cardboard, wood, or agricultural wastes is practiced at a few plants where the main refuse grinder is a rasping machine. Individual units generally have a capacity of 15 T/hr. or less.

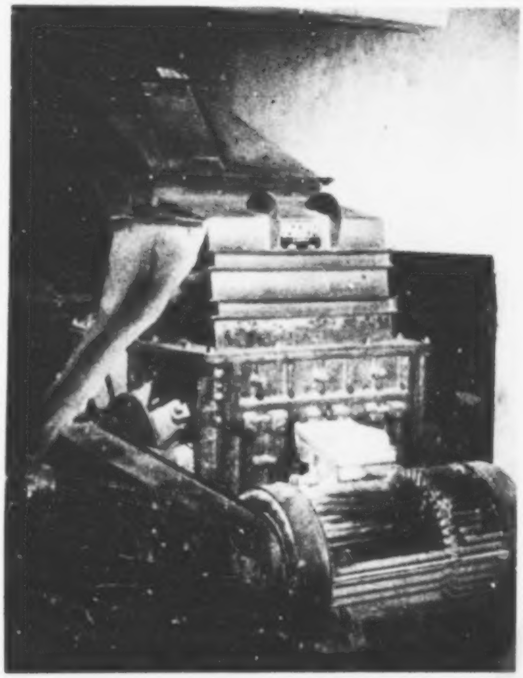

Figure 3. The hammermill at Calais, France.

Rasping Machine: The rasping machine is a raw refuse grinder that was developed by V. A. M. (6) and constructed by Dorr-Oliver N.V., Amsterdam. Its use normally follows the refuse sorting and magnetic separation operations. As shown in figures 4 and 5 the rasping machine is a large vertical cylinder containing eight heavy, hinged arms which rotate slowly horizontally above a rasp-and-sieve floor. Beneath the grinding floor is another floor over which an arm rotates to scrape the ground refuse to a discharge hole. Refuse enters above and is discharged below the machine on belt conveyers. The units are generally about 16 feet in diameter by 7 feet in height from top to discharge floor. One unit will grind up to 60 T/day, or 7-1/2 - 10 T/hr., varying greatly with sieve-hole size.

The grinding floor is made up of trapezoidal plates alternating with 1/2-inch pins and round perforations of 5/8 to 1-1/2 inch diameter. The rotating arms force the refuse over the pins and through the holes in a rasping-sieving

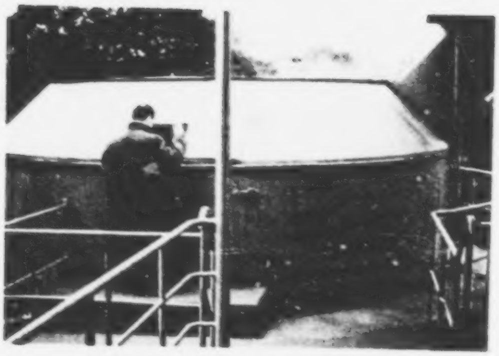

Figure 4. A rasping machine at Mierlo, the Netherlands.

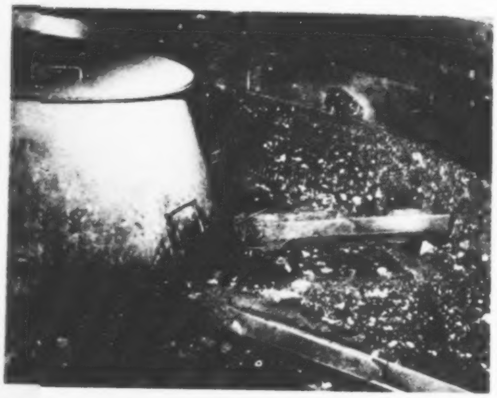

Figure 5. Interior of a rasping machine showing the hinged arms and alternate plates with pins and holes.

action. The pins extend part way up the periphery for added rasping action. The arms rotate in the speed range of 15-25 rpm. The are hinged so they can swing upward when they strike resistant material that might otherwise cause damage. Tailings are released at intervals by opening a gate from the outside, permitting the arms to push the material through the opening to a discharge chute.

Compared to a hammermill, the rasping machine is higher in first cost and larger in size, but its operation requires only about one-fourth the power and much less maintenance. The heavy arms rarely wear excessively and the rasping plates need replacement only about once per year.

PULVERIZATION

Pulverization usually follows grinding in European practice in order to reduce the size of such brittle materials as glass, ceramics, cinders and coal. Thus, shards and slivers are crushed to small size.

Roller Crusher: The roller crusher consists of two opposing steel rollers rotating slowly on horizontal axes (Figure 6). One roller is under strong spring tension towards the other roller to exert a pulverizing action as the material moves downward between them. Material is fed directly above the contac point of the rollers by means of a vibrating conveyer and discharged beneath to a belt or other conveyer. Stationary scrapers remove material that sticks to the rollers.

INERTIAL SEPARATION

Inertial separation is employed at many European plants to improve the value and appearance of the finished compost by removing some of the heavy (inorganic)

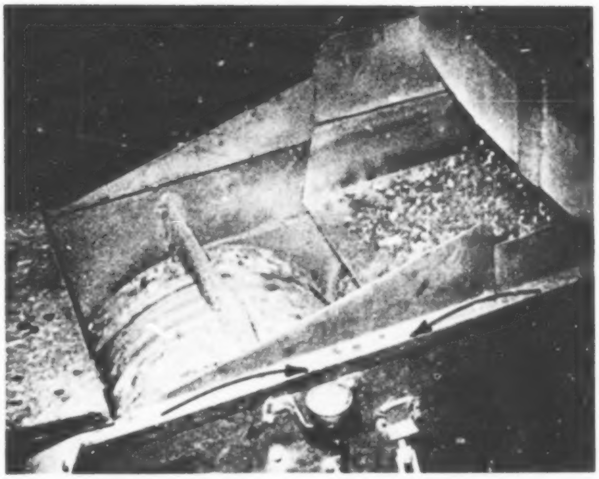

Figure 6. The roller crusher at Amelo, the Netherlands.

and resilient particles. This type of separation relies on ballistic or gravity separation principles to remove such materials as stones, glass, metals, cinders, ceramics, coal and rubber. The action of three types of inertial separators is shown schematically in (Figure 7).

Ballistic Separator: The ballistic separator consists of a high-speed horizontal rotor and large horizontal enclosure with two or three hoppers (Figure 8). Impellers, normally short pieces of railroad rails mounted on the rotor (Figure 9), strike the ground material and fling it horizontally or at a slight upward angle. The flying materials assume various trajectories along the length of the stilling chamber. Dense and resilient particles have a high initial speed and a long trajectory; light and soft particles have lower initial velocity and a shorter trajectory. About three-fourths of the length of the 25-foot chamber is used to retain compostable materials, the remainder non-compostables. There is some overlapping of trajectories. The long compost chamber may require screw conveyers to move the material to the discharge openings.

The ballistic separator serves as a grinder as well as a classifier, acting as a hammermill that strikes the material only once. The impellers and some of the plates of the housing are subject to heavy wear; the former require replacement about every week or two. A single ballistic separator may serve a plant treating 60 to 100 T/day, depending on whether it is fed ground refuse or compost.

Secator: The secator relies on gravity separation primarily to remove the heavy and resilient particles from compost (Figure 7). Compost is discharged from an inclined belt conveyer operated at a relatively high speed so that it leaves in a trajectory (Figure 10). It then strikes a vertical plate and falls on a pulley rotating in the same direction as the conveyer pulleys. The pulley is so placed that the organics land on or forward of the center of rotation and are carried with the pulley, while the inorganics land behind the center of rotation and bounce off on the opposite side. Hoppers collect the classified materials. The unit may be adjusted to rely more on either the bounce plate or the pulley for the separation.

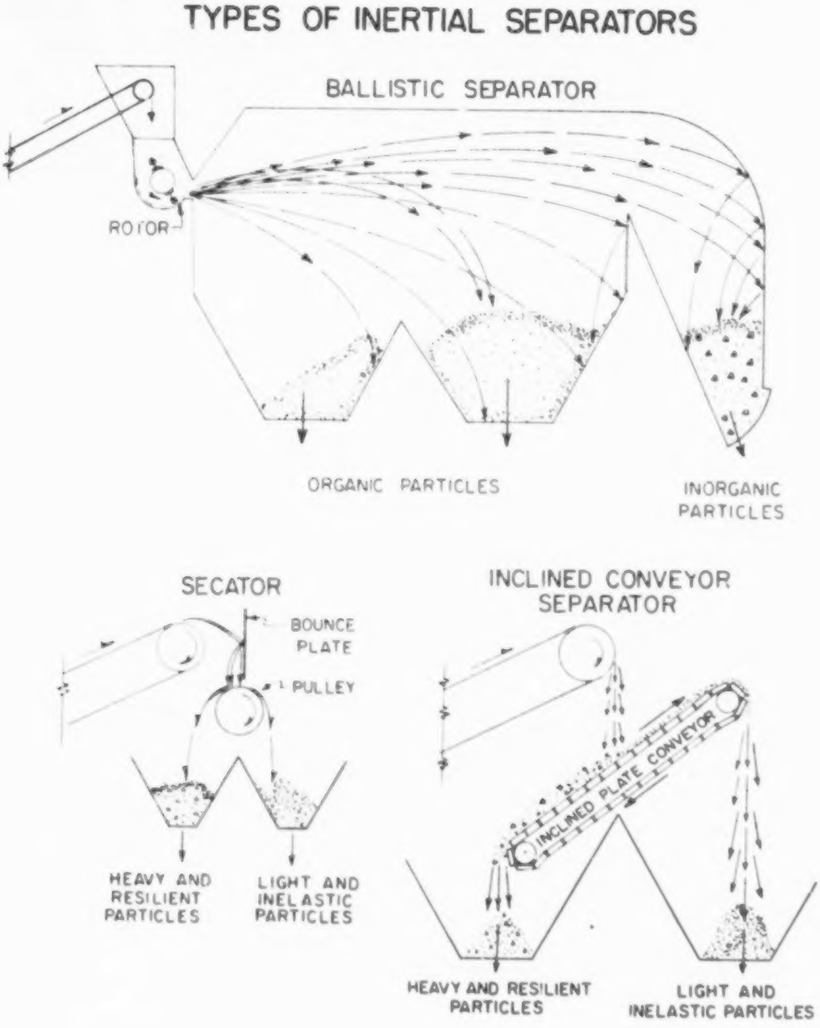
TYPES OF INERTIAL SEPARATORS
BALLISTIC SEPARATOR
ROTOR
ORGANIC PARTICLES
INORGANIC PARTICLES
SECATOR
BOUNCE PLATE
PULLEY
HEAVY AND RESILIENT PARTICLES
LIGHT AND INELASTIC PARTICLES
INCLINED CONVEYOR SEPARATOR
INCLINED PLATE CONVEYOR
HEAVY AND RESILIENT PARTICLES
LIGHT AND INELASTIC PARTICLES

Figure 7

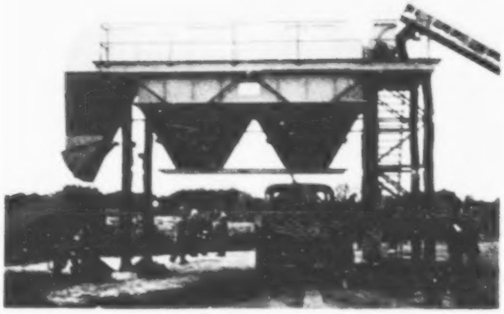

Figure 8. The ballistic separator at Enschede, the Netherlands.

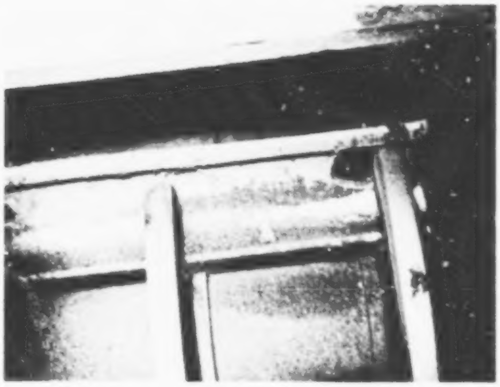

Figure 9. A ballistic separator rotor and impeller at Almelo, the Netherlands.

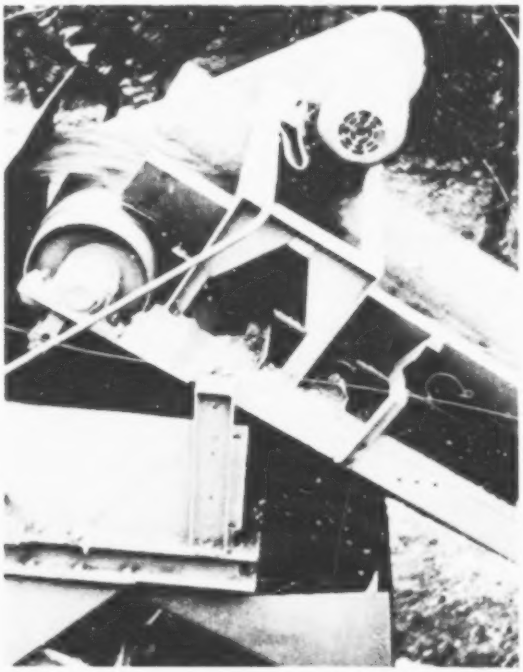

Figure 10. Compost discharging from the belt conveyor of the secator at Mierlo, the Netherlands.

Inclined Plate Conveyer Separator: An inclined plate conveyer classifier was under test at the Craigmillar plant in Edinburgh, Scotland. Figure 11 shows the overhead belt conveyer for compost, the inclined plate conveyer, and a pile of cinders and glass that has been separated from the compost. Figure 12 shows the compost discharge side of the same unit. The compost drops over the center of an 8-foot long inclined plate conveyer traveling upwardly as shown in Figure 7. The plates are of steel so that glass and other heavy particles bounce down the incline contrary to the conveyer direction. Compost remains on the conveyer and is carried up to be discharged at the opposite end. It appears that the plate conveyer could be readily adjusted as to inclination and speed for different types of materials. Scott reported,(2) however that better glass extration occurred by fine vibratory screening than by either ballistic separation or inclined plant extraction.

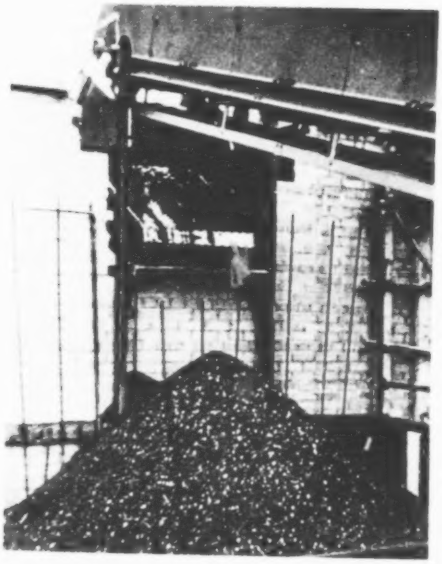

Figure 11. The inclined plate conveyor separator at Edinburgh, Scotland, showing cinders and glass extracted from compost.

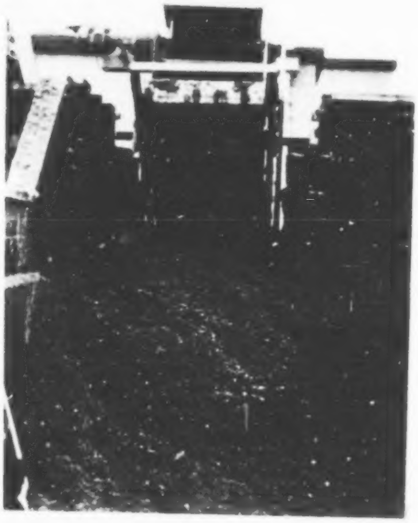

Figure 12. The compost discharge from the Edinburgh separator shown in figure 11.

In plants composting combined refuse, more than half of the cost and labor is expended in refuse separation and grinding and in compost refinement, as opposed to composting. A number of European nations have led others in the development and adaptation of various items of equipment for refuse separation and grinding. Some of the units that are briefly described and illustrated here may be worthy of trial at composting plants in the United States.

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2. A Simple Process for Composting Small Quantities of Community Wastes

by Rikard Lindström, Tyresö, Sweden

The ever-increasing contamination of soil and water through sewage systems poses a number of serious problems. Soils and wells are being contaminated by wastes reaching the soil and through open cesspools and leaking sewers. More and more lakes, rivers and coastal waters are being similarly contaminated. The absence of effective treatment plants results in enormous increases in contamination.

Sufficient treatment based on present methods requires extensive and costly transportation and treatment, including utilities, vehicles, equipment, buildings, land, and labor. High capital and operating costs required for this process indicate to some degree why it is impossible to solve the problem of public cleansing even in cities.

In most common waste disposal plants, wastes are mixed with water. This requires relatively large quantities of clean water just to serve as a transportation medium for the wastes. In sewers the wastes are transported after mixing with about 100 times their volume in water. This system is not practical, especially in areas with a restricted fresh water supply. Yet it has been considered as the only seemingly usable system as far as cities are concerned.

Simple treatment plants do not provide adequate sewage treatment but merely separate the solid wastes from the liquid. Efficient treatment plants, such as sludge and refuse incinerators, are being built in cities but are too costly for use in all areas where effective treatment plants are necessary. In certain communities it is difficult or impossible to provide sewer systems and central treatment plants due to the elevation of houses or the type of terrain, such as in very hilly terrain.

There is great need for simpler, yet effective, processes and plants which do not require transportation or complicated treatment. Because sewage with large quantities of water is difficult to treat, excreta, animal wastes, and other insanitary materials should be prevented from entering sewers. An experimentally-tested process to achieve an aerobic biological change in organic wastes is described here. The key to the process is that wastes are deposited into a naturally-ventilated chamber. They then move by gravity from this chamber into a second chamber. The speed of movement is chosen so that the wastes are substantially decomposed as they reach the second chamber.

A tank (1) (see figure 1) of impervious material such as concrete or plastic is divided by vertical partitions (5,6) into two or more chambers (a,b,c).

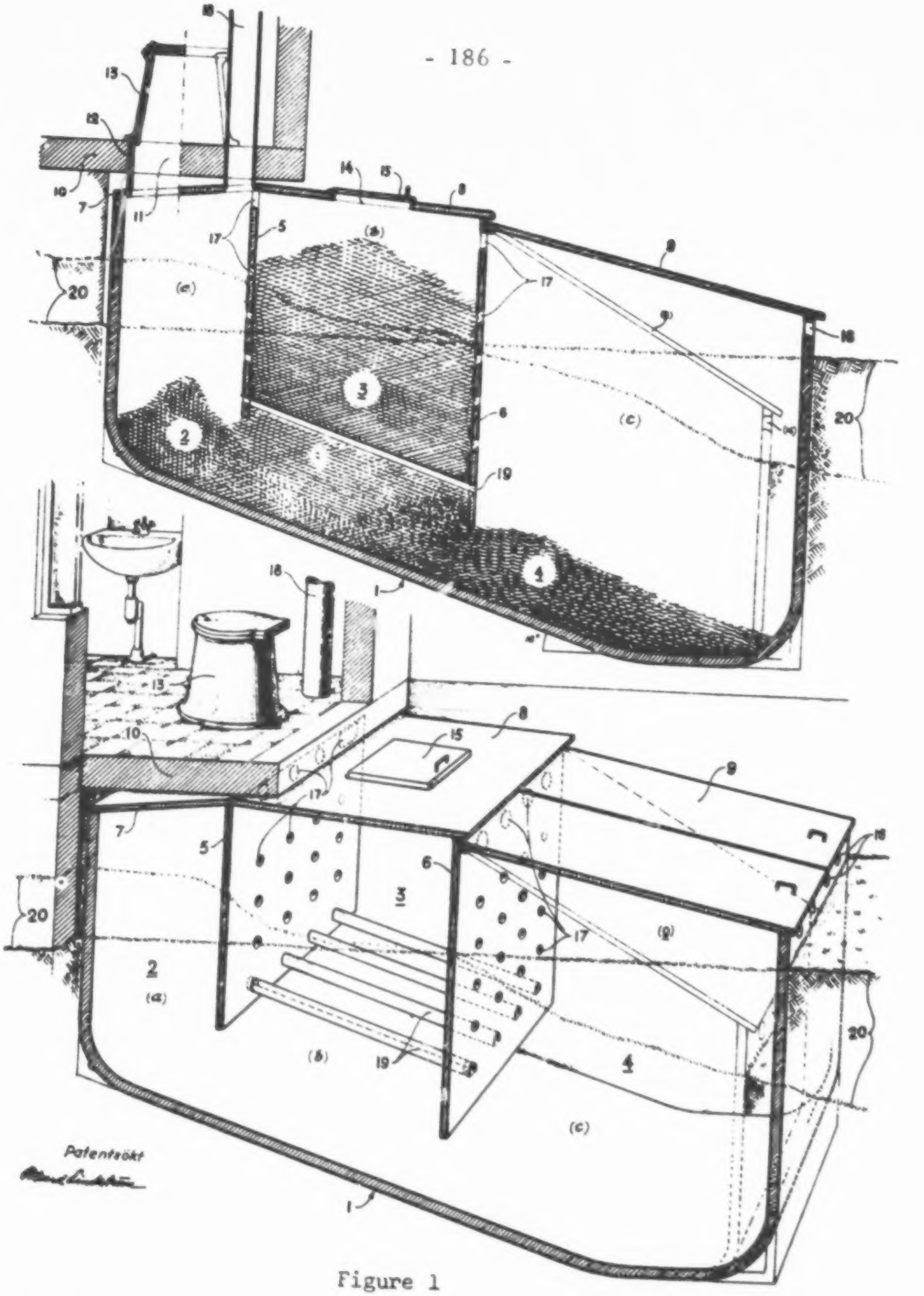

18
13
12
10
7
11
14
15
8
17
5
(a)
(b)
20
2
3
6
19
(c)
9
16
4
1
Patentsökt

Figure 1

1 Tank
2(a) Excreta Compartment
3(b) Refuse Compartment
4(c) Storage Compartment
5,6 Partitions (alt.)
7,8,9 Cover (alt.)

10 Floor (bathroom)
11, 14 Opening
12 Riser
13 Toilet
15 Lid (Rubbish shaft)

16 Air entrances (alt.)
17 Air flow passages
18 Vent stack
19 U-shaped conduits
20 Ground level

The upper chamber (a) serves as a receptacle for the feces (2), and the next one (b) holds kitchen and garden refuse (3). The lowest chamber (c) serves as storage for the finished compost (4).

The chambers are connected through ventilation holes in the partitions (17) and to the outside air through air vents (16) and a vent pipe (18) which extends above the roof of the building. The partitions do not reach the bottom of the tank but leave open flow passages so sized that, with the slope of the bottom, a suitable downward movement of the wastes occurs.

It is possible to achieve with this arrangement an aerobic biological change in wastes of all kinds, such as excrement and refuse, with a first-class manure as an end-product. This is all done without mechanism and without the addition of chemicals or water.

Depending on the desired capacity, this arrangement can be built in small or large units connected directly to the house or building from which the wastes originate, such as homes and auxiliary buildings. It serves as the toilet, as garbage container, as the apparatus for biological conversion, and as collection and storage place for the converted wastes (compost) (see Figure 2).

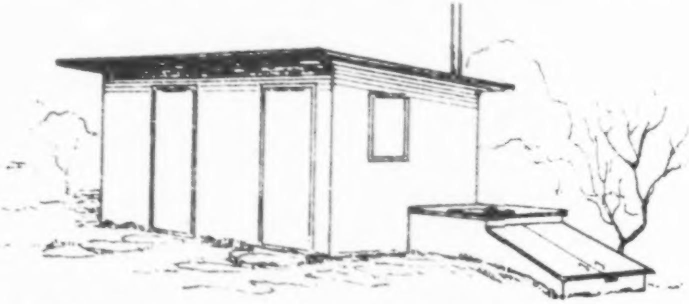
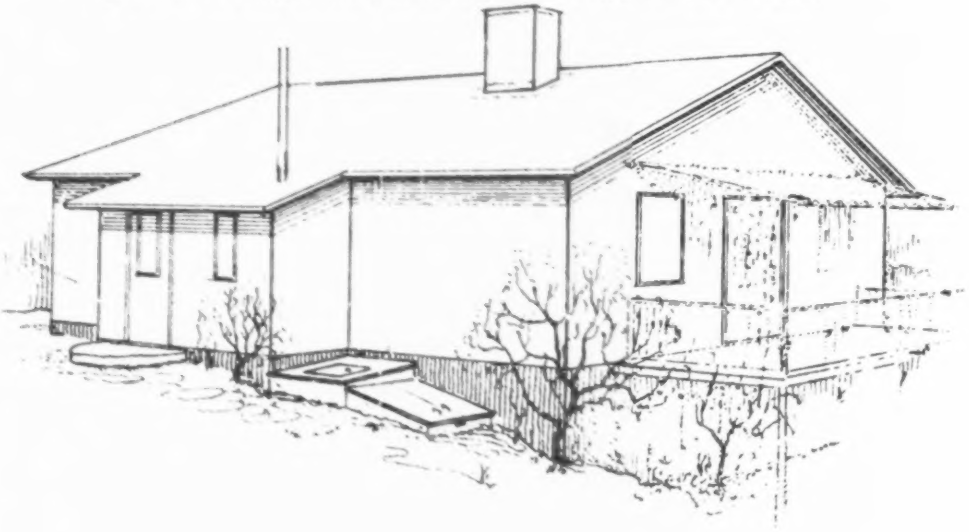


Figure 2 Arrangement partially in front of the house.



The unit should not be connected to water or drain pipes because water is not used to transport the wastes and the moisture content should not be increased above normal. Also, the unit is equipped with thick side and bottom walls which completely prevent contamination of the surrounding soil. The necessary ventilation for the desired treatment and for a complete freedom from odors is achieved through use of natural ventilation. Air circulation is accelerated by heat which is created in the conversion process. It was noted in the experimental plant that no detrimental odors were observed.

Because this system is completely independent of transportation or other auxiliary equipment, the only costs are for the initial construction. These costs are very minute compared to high-performance treatment plants connected to tight sewer systems.

The invention is primarily used in areas where no sewage treatment plant is available but also in areas where leaking sewers exist that contaminate the soil. The system is further usable in all cases where transportation and disposal of wastes, refuse, and excreta pose practical or economic problems.

Most of the tank is below ground level in a firm, well drained sub-soil. When the tank adjoins a building, it will be placed near an outer wall of the building and entirely or partially beneath the floor. If used in a house or auxiliary building, it will usually have two receiving chambers, one of which is connected to the toilet.

The air entrance (16) and vent pipe (18) are covered with fine wire screens to keep out insects or other vermin. The illustration also shows several inverted U-shaped conduits (19) in the bottom of the refuse chamber. These conduits, which connect partitions 5 and 6, run essentially parallel to the bottom of the tank in its longitudinal direction. They permit a larger amount of air to reach the refuse in the lower portion of the center chamber. This is particularly important in installations with deep refuse chambers in which the wastes are heavily compressed. As previously mentioned no chemicals such as chlorinated lime should be added to the tank because the bacteria needed for aerobic decomposition would thereby be destroyed. No water should be added as it has been shown that normal moisture of the wastes is suitable for the conversion process. Wastes of highest moisture content are added in the excrement chamber. Urine, which represents the major part of moisture in excreta, is spread on the dry mass in the refuse chamber. There is no free moisture in the storage chamber. Rich bacterial cultures developing in the mixture of excrement and refuse provide extremely rapid decomposition, considerably faster than with refuse alone. Decomposition occurs mainly in the refuse chamber. Many factors are involved in planning an installation as discussed below.

The volume of excrement is a small part of the total waste volume from a household. The first chamber should be large enough so that the contents use only a small part of the tank depth. This keeps air passages between the excrement and refuse chambers open. In initial use, it is recommended that first a layer of garden wastes or soil and kitchen wastes be added as this will absorb the moisture from the feces.

Garden refuse or soil add the important nitrate bacteria. These increase slowly but must be present in adequate numbers later so that a complete change of the ammonium carbonate into ammonium nitrate occurs.

The vent pipe must be fairly high (comparable to a chimney) especially in hemmed-in locations.

The tank can be advantageously built entirely in the house (cellar). When located in the cellar there is no extreme cooling in winter. If the installation permits, the vent pipe can be led into the chimney.

In the illustration of a tank for a normal household, the length of excrement chamber can be so chosen that it may be connected to the building. The inside width can be about 1 m for a tank of smallest practical size.

The top of the refuse chamber should be close to the ground level to permit easy access to the interior. The refuse chamber volume is about 1.5 m^3. Dimensions of the chamber may be varied--the primary requirement being a good air flow to the refuse mass. If the refuse chamber is deep, too much pressure exists and insufficient air is provided through the U-shaped conduits. These are inserted to form a grating running parallel to or slightly less inclined than the tank bottom (see figure 1). The inner depth and width of the conduits should not be over 5 cm and the distance between them should be about 15 cm. Screens over the conduit openings should prevent clogging when the layer of excrement reaches them.

The storage chamber should have a relatively shallow depth and large surface area which is exposed to the air. Also, the volume of this chamber should be sufficiently large to permit long-time storage, such as a year. The compartment length should be at least 1.5 m for ease in removing the contents.

Vent holes in partitions should be distributed over the entire surface area of the partitions. The upper vent holes should be relatively large for adequate air circulation in the tank and aeration of the upper layer of refuse. Yet the length of air passages should be no larger than necessary to prevent stoppage by wastes. The partitions can be formed by perforated plates or screens. The one between the excreta and refuse compartments should be only far enough above the bottom to prevent the refuse from taking up too much room in the excrement compartment. Yet there should be a certain mixing of the various wastes which has a favorable influence on moisture distribution, porosity and aeration.

The partition between the refuse and storage compartments is designed to prevent nondecomposed wastes from falling into the storage chamber. The opening at the bottom is of such height that only the refuse that has been converted can enter the storage compartment. In figure 1 this height is about 30 cm. The height of opening can be adapted to the volume and depth of the refuse compartment and the length of the storage compartment.

Aeration of the wastes is of primary importance in the decomposition and determines the planning of the tank and compartments to a great degree. Sufficient care must be taken so that the area in contact with the flow of air is large enough--achieved best with shallow depths and large surface area of the contents. This is especially critical in the excrement and storage compartment. If desired, the refuse chamber can be relatively short and deep because aeration is provided through vent holes in the partitions and through the air conduits.

The tank can be compared to a furnace. The excrement and refuse chambers are equivalent to the combustion chambers; the storage compartment is equivalent to the ash chamber; and the vent stack is equivalent to the chimney. When parts of the tank walls and cover are of translucent material, the heat from the sun's radiation increases the conversion process.

The slope of the tank bottom provides continual movement of decomposed refuse to the storage chamber as additional wastes are added to the other two compartments. When more refuse is added, the lower layer is compressed and decays. The waste volume is reduced to a fraction of the original during this process. When the depth of garbage in the refuse chamber is great, the material is then pressed through the opening into the storage compartment independently of the bottom slope. Even if the bottom slope is insufficient, there occurs a state of balance. Excess slope results in inadequately decomposed wastes entering the storage compartment and accumulating in the lower part. This is obviously difficult to remove. A further disadvantage is that the moisture content easily becomes excessive and the oxygen content too low such that anaerobic processes occur in the lower layer. Experiments showed that the bottom slope must be between 1:4 and 1:3 (i.e., 14° and 18.5°). Even minor deviations from this range causes improper operation.

The bottom slope need not be uniform lengthwise nor is it necessary that the floor run evenly. The profile can be curved or stepped. In one example the upper part can be sloped 1:3, the middle 1:3.5, and the lower 1:4.

When the total tank length is about 3.5 m and the slope is about 16°, the elevation difference of the bottom is about 1 m. The depth of excrement chamber is then at least 1-1.5 m.

The tank cross-section need not be rectangular but can be made of cyclindrical elements. It is also possible to build the unit in one piece using a single concrete pouring or prefabricated parts. These changes permit variations in form and size. As the layout of the tank is considered, the various parts can be changed to conditions and type of usage. It is possible to build more than the three compartments illustrated. If only two are provided, one serves as the receiving chamber and the other for storage.

If the plant is at a central point for biological conversion of organic wastes, then it will not be directly connected with a tiolet. A major advantage is that the process is fully automatic and the end product contains large amounts of humus-forming substances.

This composting process and its plans (patent pending) were successfully tried and improved by the author over several years. It has created interest among Swedish authorities and will be closely studied soon.

3. An Economic Method for Dewatering Sewage Sludges and Their Preparation for Spreading As Fertilizer of Soil Conditioner (Dutag-Albert Process)

by R. L. von Reppert, Wiesbaden

A new process is described which economically solves the problems of dewatering sludges and their use in agriculture. By this method, an easily distributed granulated fertilizer or soil conditioner can be produced which is suitable for shipment, storage, and machine spreading.

Dewatering on drying beds of fresh or digested sludges, which have 5 - 10% solids content, from wastewater settling tanks, is often inadvisable for municipalities due to the odors and the large area required. Sludges may be processed by flocculation and mechanical dewatering methods by means of centrifuges or filters.

Sludges produced in this way, consisting of inorganic and organic solids and about 30 - 60% water, are often dumped, composted, or incinerated. Valuable humus materials are lost for agriculture by dumping or burning the dewatered sludge and, because of the decline in humus as shown in several publications, the natural cycle of material is broken.

The market for wet or dewatered sludge is not assured. The reason is that chemical fertilizers today are produced entirely in granular form which is easier to transport and spread by machines. The new process should solve the problems of dewatering the sludges and of their disposal since it produces a needed soil improver which provides organic constituents.

Many studies have shown that ground basic slag is preferred as a flocculent for sludge. Mixing one liter of sludge, which contains 7% solids, with 700 g of ground basic slag, produces filter capacities of about 300 $l/m^2/hr$. The filter cake has a water content of only 20 to 25% and could easily be crumbled for spreading with a simple drum granulator or other grinding device. In this way about 10 g of basic slag is present per gram of dry sludge solids.

However, the material thus produced can be "fortified," by a method described later, to produce a soil corrective with a low level of P_2O_5, such as 6%, or to produce a phosphoric acid fertilizer with less organic matter but with a higher content of phosphoric acid, such as 11% P_2O_5. To attain this, sludge from a digestion tank does not need to be flocculated with basic slag, but only dewatered in a centrifuge. Such machines, operating by centrifugal separation, can remove 60 to 90% of the water from the sludge. These sludge cakes still have a moisture content of about 50%. In the new process only the centrifuged flow is flocculated; this flow generally has a solids content of 1.5 to 3%. Because of the reduced solids content, less basic slag is necessary, for example 270 g/l of ground basic slag were required for a sludge with a 2.2% solids in order to attain a filter capacity of 300 $l/m^2/hr$, while 700 g/l were required with sludge containing 6.6% solids to reach the same filtration rate.

With a rotary filter, operating without an auxiliary filter bed, the filter cake (Figure 1) can be removed from the drum by means of scraper cords. The filtrate is clear and can be returned to the influent of the biological plant without

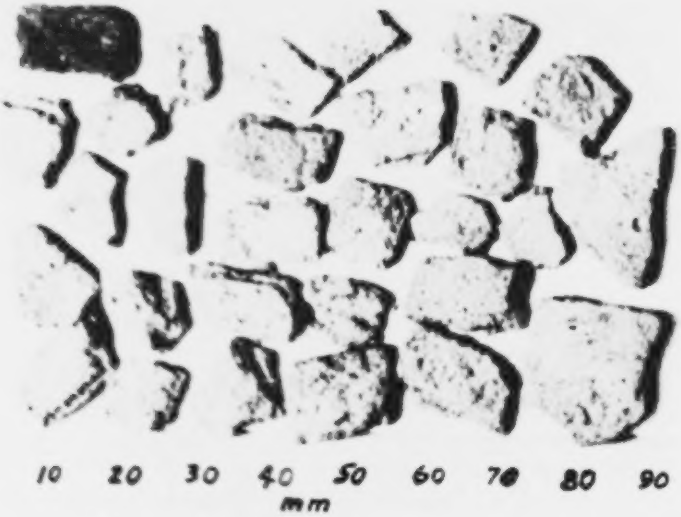

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Figure 1

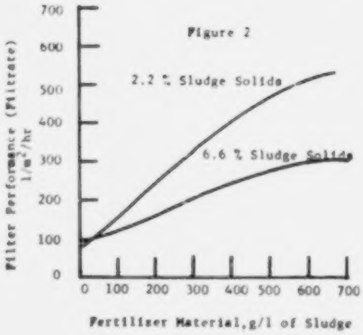

Figure 2

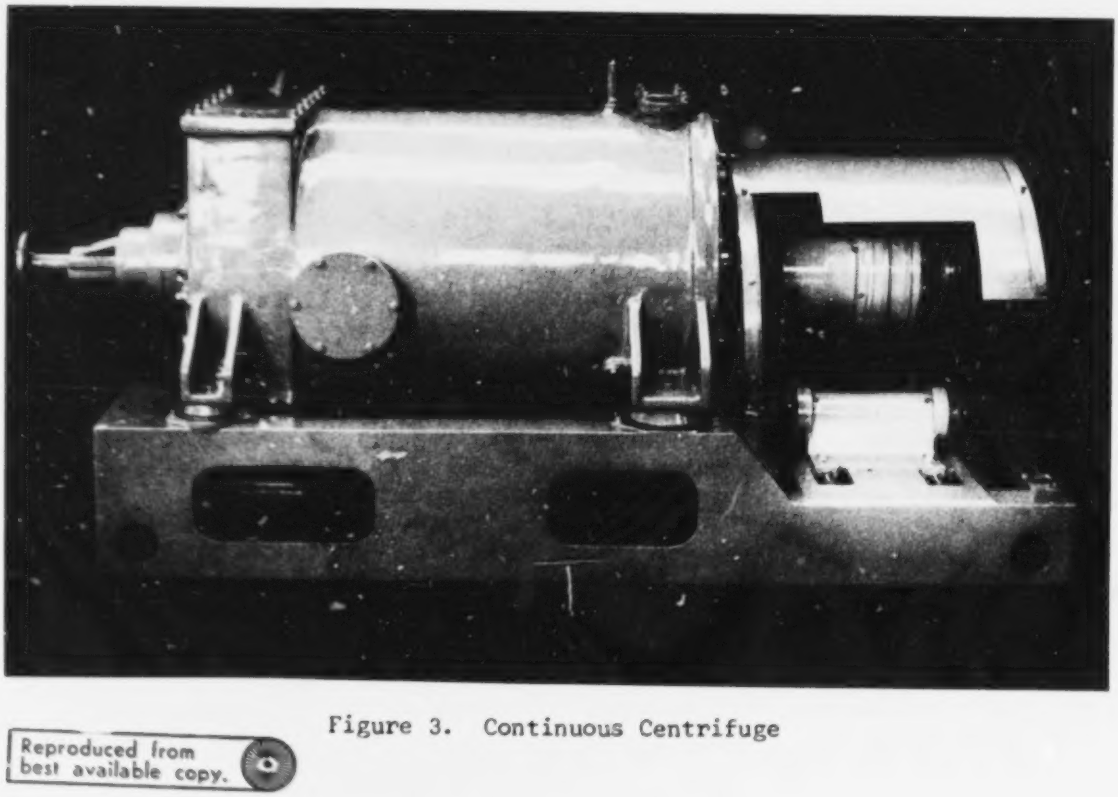

Figure 3. Continuous Centrifuge

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hesitation. With smaller quantities of coagulant, it is advisable to precoat the filter with a filter aid. One can also filter sludge containing ground basic slag at higher temperatures and perhaps under pressure in order to reach ecnomical filtration rates.

The graph in Figure 2 shows the interdependence between the filtration capacity and the use of ground basic slag. Sludge solids concentrations of 2.2% and 6.6% are given as examples.

There is also an interdependence between the capacity of rotary vacuum filters and the concentration of solids of the filtered sludge when flocculated with various dosages of fertilizer materials (without filter precoating).

The solids separated by the dewatering centrifuge, and perhaps shredded, can be mixed intensively with the filter cake from the rotary filter and formed into particles as previously mentioned.

Following are some examples of mixtures:

Separating 70% of the sludge solids and flocculating the centrate with 10 g of ground basic slag per g of sludge solids, produces a fertilizer with the following composition: 53% slag (15% P_2O_5), 18% sludge solids, 29% water. This product has about 8% P_2O_5 besides other valuable organic constituents when using ground basic slag with 15% P_2O_5.

When flocculated with only 5 g of ground slag to 1 g of sludge solids, and the same preseparation in the centrifuge (it is advisable to use filter precoat), the finished product will contain about 40.5% ground basic slag, for a total of 6.1% P_2O_5; 27% sludge solids; and 32.5% water. For a product with greater P_2O_5, the original sludge can be flocculated with 15 g ground basic slag/g sludge solids resulting in 75% slag, for a total of 11.25% P_2O_5; 5% sludge solids; and 20% water. The small content of organic matter is enough of a binding agent to change the ground basic slag to a size that will not be dusty. Instead of ground basic slag, heated phosphates or ground rock phosphates can be used with similar good results, but they require the addition of lime for pH control.

The quantities of materials containing phosphoric acid can be reduced considerably when the centrate mixed with them is heated or filtered under pressure. Then the filter cake from the rotary filter has a water content of less than 20%. In the most favorable case, with the same good filter effects and capacities, only 1 g of ground basic slag per gram of solids is needed, compared to 10 g previously mentioned.

It is also possible to add other components to the centrate and filter residues, such as potash and nitrogen salts, pesticides, and others. The mixed product can be formed into granules of, say, 3 mm in length and diameter (Figure 4) with a simple granulating device.

These raw granules are inclined to agglomerate. If more lasting particles are desired, a binding agent such as sulfite waste liquor can be added into the mixer, but it is also possible to dust the granules with dry ground basic slag so that afterwards they no longer agglomerate but are good for transporting and storage. Very strong granules can be obtained if the raw granules are powdered with rock phosphate and then sprayed with sulfuric acid: the rock phosphate shell is attached to produce mono-calcium-phosphate. The heat of reaction at the same time results in drying and reducing the water content to about 5 - 10%. Figure 5 shows granules that were so treated. Figure 6 shows a flow sheet of the plant necessary for the method.

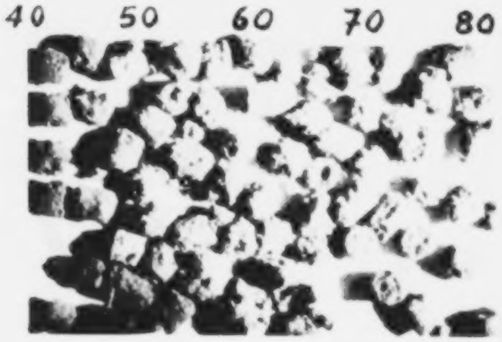


Figure 4

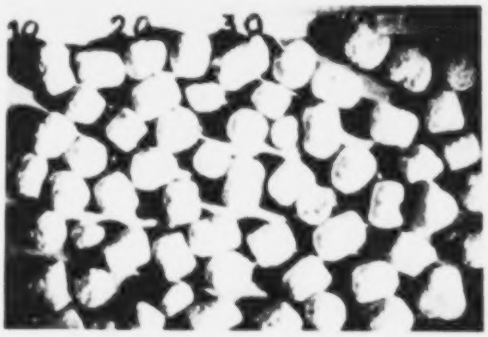


Figure 5

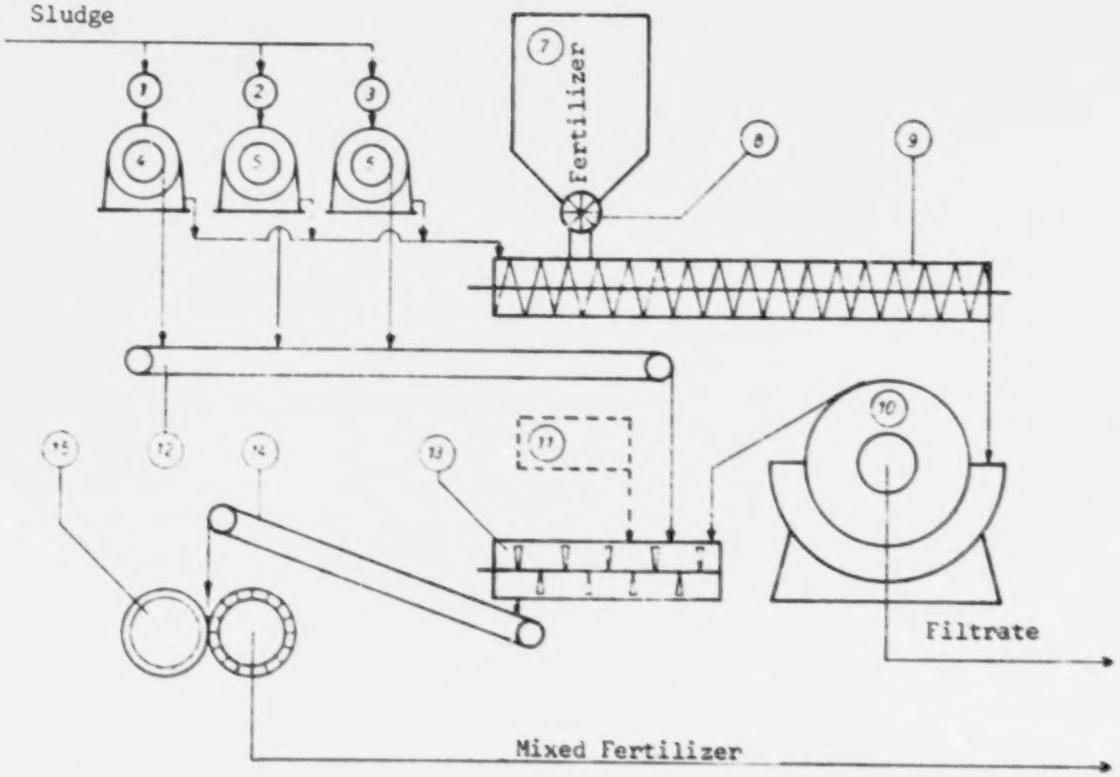
Costs of sludge dewatering are less for municipalities because the filter cake containing phosphoric acid can be sold as a fertilizer or soil conditioner, depending on the content of inorganic nutrients at the usual prices, or perhaps with a small extra charge for the organic content and the granulated form. This fact is important since the flocculent is itself a source of plant nutrients.

Even when municipalities assume the costs for dewatering sludge and only debit the expenses for transporting the flocculating agent (ground basic slag) as well as for packing, storage, and sale of the finished product, including the price of the fertilizer or soil conditioner, the following analysis is given:

Cost Calculation of a Plant for Processing 17 m^3/hr of Sewage Sludge in the Combined Dewatering Process--Centrifuge and Vacuum Filter

a. Investments:

Costs of building and storage bin for fertilizer material	DM	350,000
Costs of equipment including installation of railroad siding	DM	593,000
Planning, Engineering	DM	157,000


Sludge
1
2
3
4
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6
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Fertilizer
8
9
10
11
12
13
14
15
Filtrate
Mixed Fertilizer

Figure 6

Legend

1-3	Sludge feed pumps	10	Rotary vacuum filter
4-6	Centrifuges	11	Container for additions
7	Fertilizer storage bin	12	Conveyor belt
8	Bucket feeder	13	Mixer
9	Continuous mixing screw	14	Conveyor belt
		15	Granulator

Contingencies	DM 100,000
	DM 1,200,000

b. Annual Costs:

Amortization, 3% of building	DM 10,500
Amortization, 10% of equipment	DM 85,000
Interest, 7% of the total sum	DM 84,000
Repairs, 5% of the equipment	DM 34,650
	DM 214,150

c. Power Costs:

138 KW/hr (maximum) at 0.1DM, per year	DM 119,000

d. Wages and Social Charges:

3 men at 6 DM/hr, per year	DM 155,000
Total Annual Cost	DM 488,150
Costs per m^3 of sludge	DM 3.33

A corresponding cost calculation for a smaller plant of 6 m^3/hr of sewage sludge was selected and showed expenses in the amount of 3.92 DM/m^3.

In the first example, if a fertilizer with a high content of ground basic slag is produced, the centrifuges may be deleted; the mixing equipment is no longer necessary if no further components are added to the fertilizer. Under these conditions, the following calculation is made:

Cost Calculation of a Plant for Processing 17 m^3/hr of Sewage Sludge
Dewatered by Vacuum Filter

a. Investments:

Costs of building and storage bin for fertilizing material	DM 290,000
Costs of equipment, including installation of railroad siding	DM 372,000
Planning, Engineering	DM 110,000
Contingencies	DM 70,000
	DM 842,000

b. Annual Costs:

Amortization, 3% of building	DM 8,800
Amortization, 10% of equipment	DM 55,200
Interest, 7% of the total sum	DM 69,000
Repairs, 5% of the equipment	DM 22,000
	DM 155,000

c.	Power Costs:		
	100 KW/hr at 0.10 DM, per year	DM	87,000
d.	Wages and Social Charges:		
	2 men at 6.0 DM/hr, per year	DM	107,000
	Total Annual Cost	DM	349,000
	Costs per m^3 of sludge	DM	2.38

A detailed breakdown of the costs will be furnished to interested persons.

The question of whether the fertilizer produced can be sold to the extent it is available in considerable quantities is, of course, of greatest importance. This is only possible with high additions of ground basic slag or other materials containing phosphoric acid when the farmer changes over to the use of such granulated compounds of sludge and ground basic slag. The price of the product might not be essentially more than the usual price for the corresponding contents of inorganic nutrients.

A soil conditioner with possibly a high percentage of organic substances and a small percentage of inorganic nutrients is preferable for market gardening, hops and vegetable cultivation or for special soils poor in humus.

But also when large quantities of fertilizers containing ground basic slag or soil conditioners cannot always be sold, the plant, especially when equipped with dewatering centrifuges, can be adapted to the necessary requirements. For example, the sludges discharged from the centrifuges and perhaps from the rotary filters can be composted together with refuse or can be incinerated. If the sludge cake is burned, the remaining ash is especially rich in phosphoric acid and might be used as a plant nutrient as in methods developed by Dutag.

An additional advantage of using ground basic slag, powdered rock phosphate, or other suitable fertilizer materials as flocculants is the fact that the fertilizers and soil conditioners produced by this method can be granulated in a size suitable for machine distribution. In this procedure, the losses and dust nuisances now prevalent in distribution are completely avoided. At the same time, the nitrogen and potash components and the organic substances in the sludge are favorable to plant growth.

It is therefore possible to produce either fertilizers rich in phosphoric acids from the use, under certain conditions, of sewage sludge and nutrient materials used as flocculents, or simple soil additives with only a few inorganic nutrients.

As the sale of such quantities of fertilizers or soil conditioners will probably not always be possible on a large scale, especially in larger cities, it is useful when the products thus obtained are incinerated together with refuse. The remaining ash, rich in P_2O_5, can be processed into fertilizer by adding inorganic nutrients or can be used again as a flocculating agent.

In summary, the method herein described of Düngemittel-Technik AG, Barfüsserplatz 6, Basel, Switzerland, provides economical means for all towns and cities to solve the problem of sludge dewatering and preparation as fertilizer or soil conditioner. The sludge and refuse problem has possibilities of solution by this process which may be of interest in future treatment plants.

4. Mulch or Compost? by Dr. Eberhardt Spohn, Heidelberg (From *Städtehygiene*, #2, 1963)

Dr. Banse said in his paper (1) at the 2nd International Congress of IRGR, 1962, Essen: "Just another word about the term 'ripeness' as related to the composting process. In German the word ripeness not only means completion of the biological process, but it also infers an expression of value. A ripe apple is worth more than a green one. With wine one speaks of a ripe vintage as meaning of higher Oechsle-degrees and lesser acidity as contrasted to an unripe vintage. We also know finally what is meant by an unripe boy. Therefore when we speak of a ripe compost there is an understanding of a more-valuable compost as compared to an unripe compost. Such an opinion of value can not have an over-all validity and would only cause confusion. I therefore recommend that one speak not of ripeness but of completed decomposition and not of ripeness test but of decomposition test."

Dr. Banse and some other experts agree that a compost should contain as much organic matter as possible in order to be especially effective and concentrated. This view can be accepted insofar as compost is used on the surface such as in vineyards and in some other application areas. It does not come in contact with plant roots but has the chance to undergo sheet composting, particularly if applied in the fall. Soil organisms decompose it and it finally mixes with the soil. This process is also called mulching. It has been widely used for only a short time, at best for a few decades, even though patterned after forest humus formation from fallen leaves. Material slow to decay is favored in mulching for it retains its soil-covering effect for a long time. Some favorite materials are shredded hay, straw, corn stalks, or other similar wastes. Somewhat faster decomposing material is of course also suitable, such as processed urban refuse which has been through precomposting for decontamination. Such material is obtained in several processes such as the Dano and Earp-Thomas processes and probably that of the plant which will shortly be operating in Schweinfurt. The windrow process of composting of ground refuse in the open can also be interrupted at the appropriate time. The fact is that such "unripe" compost is predominant on today's market.

In some processes there is danger that part of the material will become anaerobic due to improper handling. This can be recognized by a typical nauseating foul odor. Anaerobic microorganisms are antagonistic toward a favorable environment for soil organisms. They should never be added to the soil even though there are still farms who believe the motto "What stinks, fertilizes." If one does not incorporate such material into the soil but places it on top as a mulch, it soon loses its bad odor and the microorganisms are changed so that such a "slightly smelly" and uneconomical processing may pass without damage.

As stated, a high content of organic substance is desired for mulching. This material should preferably be not too greatly decomposed. Such raw compost is recognized by the fact that it heats up in an insulated container (2) or mildews heavily in piles of about 40 percent moisture content. The method of mulching and sheet composting is extremely economical because the frequent turning needed for finished compost is saved.

The gardener has thought of compost as something different from this for thousands of years. He wants to bring compost, alone or mixed with soil as necessary, directly in contact with seeds or to plant seedlings in it. The compost must be ripe. This is also the experience of thousands of years. It must have a pleasant forest soil smell, never anaerobic, and it must not mildew. There are a number of plants that are more or less sensitive to half-ripe compost, but others are very sensitive. In addition, planting mix or compost-soil mixtures should not be too fat; that is they should not be too rich in organic substance. Thus the requirement of highest possible organic matter in mulch is not always valid. Winter refuse, with its high ash content, can be very valuable for soil improvement in many cases. With ashes, especially thorough composting or ripeness is required. This was pointed out recently by Rohde (3).

When a gardener buys compost usually used for planting purposes, he expects to receive ripe material that is foolproof even for the most sensitive plants. He cannot measure the degree of decomposition and usually does not want to bother with after-composting. He will be led astray if he is sold as "compost" a raw or partially composted material from one of the above high-rate processes; this still occurs sometimes.

In view of the above, it is clear that a finished compost for planting will be more expensive than a mulch compost. Due to greater decomposition it will contain much less volatile matter than a mulch compost. It is therefore incorrect to evaluate a compost by its ripeness or by its organic content. The evaluation must come from its usage. If one considers compost to be finished, ripe compost as used for decades for planting, then it is incorrect to consider pre-compost or raw compost, as used in mulching, as compost. A new word would have to be created; we will not do so here. The word root 'compost' came from "put together" and, since urban refuse is put together from many ingredients, it is therefore appropriate to use the words "pre-compost" or "raw compost." Dr. Banse could still fear misunderstanding of this. It is therefore suggested that one not speak of compost as such but rather mulch-compost on one side and plant-compost on the other. With these clear designations, misunderstandings will disappear. Producers of finished products will then find it unnecessary to use degree of ripeness in their evaluation in order to protect themselves against the judgments of agricultural experiment stations which discriminate against plant compost by assessing it only on its content of volatile matter without considering that organic substance is something living and that the living quality is more important than quantity. The saurians, with their large bodies and small brains, did not become extinct by accident.

Quality must always be judged by its use purpose: mulch or compost.

References:

1. Information Bulletin No. 15, IRGR, August 1962

2. Spohn: Fortschritte bei der Hersfellung von Kompost, Städtehygiene 85, 1962

3. G. Rohde: Rückstande aus Heizungsanlagen in der Kompostierung, Städtehygiene, 491, 1962

5. Grinding Harbor and Bulky Refuse in Amsterdam by Dr. E. Andreas, Münster, Westphalia.

In this large harbor city, there is always a lot of harbor refuse and bulky refuse consisting primarily of large pieces. Incineration of these large items is impossible in the old incinerator. The Hazemag Company showed representatives of the City Cleansing Department the practicability of grinding furniture and other bulky wastes in a hammermill. After this demonstration, the company was awarded a contract to construct a grinding plant for bulk and harbor refuse next to the old incinerator. The most important part of the grinding plant is the Impact Crusher SAP 5/M with a throat opening of 1.5 x 3 m. With this large an opening, it is possible to eliminate sorting of refuse. The crusher weighs about 52 tons and the rotor about 13 tons with a centrifugal movement of about 16,000 kg/m^2. The mill is powered with a 160 kw, 3-phase motor with short-circuit anchor; this is possible because a starting clutch is used on the motor shaft.

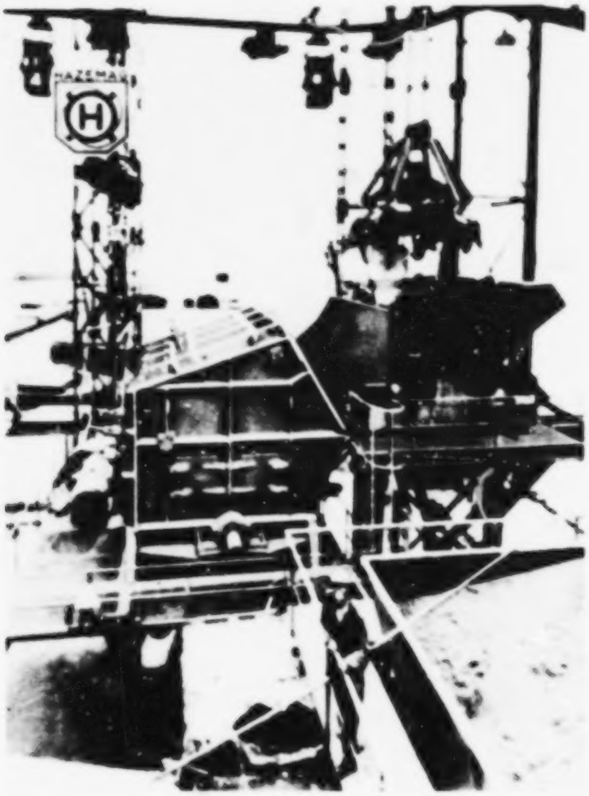
After more than 10 months of continuous operation of about 8-10 hours/day, it is concluded that the plant completely fulfills its purpose, especially the impact crusher. The amount processed is 120-200 m^3/hr. and the average energy used is about 70 kw. Untill now, little wear has been noticed, except that it has been necessary to turn the hammer arms in the other direction, an operation which can be done in a few hours. The refuse consists mainly of large crates, partially reinforced with iron; old furniture; mattresses, with or without feather stuffing; barrels; refrigerators; harbor masts; ship covers; carpets, which are often tied; pieces of stone and concrete; etc. The ground refuse can be burned without difficulty in the old incinerator with a high degree of efficiency as it is largely homogenized.

Idling energy of the grinder is 38 kw and maximum energy during starting is 128 kw. A pole of 350 mm diameter x 3.5 m length was ground in 15 seconds during which time a maximum load of 63 kw was experienced. Thus the motor is quite liberally designed, but this is necessary because there is a steep increase in power for a short period when a tied carpet or similar object enters the mill. The motor cannot fail at that time.

Bulk refuse arrives in freight barges and is transferred by a grab crane to a vibrating conveyor. The conveyor provides an even flow of refuse to the mill. At the discharge of the mill, there is an armored vibrating conveyor which discharges ground refuse to a long conveyor belt that moves to the incinerator. This arrangement was required because local conditions dictated the use of some existing equipment.

This same type of impact crusher is being built for the incinerator in Stuttgart and is planned for Hamburg, Rotterdam, and other harbor cities.

The next smaller impact crusher for bulk refuse has a throat opening of 1 x 2 m and a capacity of 70-100 m^3/hr. Smaller mills of type M can be built. Their use will not always permit grinding all materials without sorting.



Hazemag Impact Crusher, Type SAP 5/M with throat opening 1.5 x 3.0 m, for grinding bulky refuse.

6. Book Review

Theories and Practices of Industrial Waste Treatment by Nelson Leonard Nemerow, Syracuse University. Addison-Wesley Publ. Co., Inc., Reading, Mass., USA/10-15 Chitty St., London W.1, ENGLAND, $15.

This book serves not only as a text for graduate students in Public Health Engineering but also as a valuable reference for the practicing Public Health Engineer in industry and government.

As the title indicates, theoretical and practical treatment methods for industrial wastes are found in this book. It also describes a few specific problems and their exact practical solution. As the author uses his own experience and research, he makes it easily understandable by the reader why a certain treatment is to be recommended.

The book has four main divisions. The first part treats the necessary basic information and describes the most important processes. The second part gives many theories concerning industrial waste treatment and several new processes for the disposal of loose solid organic material. The third part describes modern practical processes and gives a realistic analysis of the human, public and economic factors influencing the realization of scientific waste treatment theories.

The last five chapters give separate treatment of the most important industrial wastes, a complete topic ordinarily requiring an entire book. Here is a condensation of the source and characteristics of all types of wastes as well as the most suitable treatment methods. The author gives over 2000 literature references classified according to the types of wastes discussed; this will help the engineer find the solutions to various waste treatment problems.

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NO. 19

DECEMBER 1963

Ferguson, Brooks & Kelly, translators
John S. Wiley, editor

Editorial Note (Zürich Editor):

A closed conference was held in Giessen, Germany, April 24-26, 1963, by the research group of Universität Giessen (Prof.-Dr. Glathe) and EAWAG (Prof.-Dr. O. Jaag). In this and the following numbers of our bulletin, we shall publish some of the lectures from this confernece.

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1. The Influence of Various Composting Processes on Non-sporeforming Pathogenic Bacteria by Dr. K. H. Knoll (Hygiene-Institut der Justus Liebig Universität, Giessen. Director: Prof.-Dr. B. Kemkes).

The removal of residential refuse is primarily a hygienic task and obligation. The tragic situation in Zermatt (typhoid epidemic in winter of 1962-63) has contributed greatly to the fact that this task is now taken seriously by those who, till now had little to do with the matter.
It may seem ironical that such tragedy, caused by insanitary refuse disposal, occurred in a country which has earned much credit in refuse disposal and has been to us in Germany, the example of regulated refuse handling practices. We do not wish to gloss over the Zermatt situation, but we cannot claim that such an extensive epidemic is impossible in Germany. These short-cuts in refuse disposal may occur anywhere at any time today, even where refuse disposal is conducted with a seriousness suitable to a basic sanitation program. A clear challenge for the decontamination and disinfection of wastes from human households resulted from this epidemic.

It must be emphasized that it is not only the refuse that poses a hygienic problem. If such were true, then we could solve the case by sterilization and volume reduction by incineration. However, the problem also exists with sewage sludge. In sewage, and consequently sewage sludge, we find those pathogens which can cause a large epidemic, as clearly shown in Zermatt. Sludge must therefore be classed as a most important factor, and we must be careful in our discussion to speak only of refuse elimination or utilization. But refuse provides an ideal way for us to solve the sludge decontamination problem by the combined composting of refuse and sludge. This method not only meets all hygienic requirements, but enables broad consideration of the individual interests of all participants.

By what manner can the pathogenic bacteria, entering in sludge with the refuse as raw composting material, be rendered avirulent, weaker, or be eliminated; and when are the sanitary requirements of a composted product fulfilled?

In spite of the variations in the materials, self patterns and a fixed system are derived in which all composting processes operate; be it simple windrow composting, technical, or even automatic processing in digesters. From a hygienic viewpoint, the raw material goes through several decomposition temperature zones in which not only the temperature, but also all processes (which we classify as "antagonistic occurrence" or biological

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self-purification") are responsible for the destruction of foreign compost germs and substances. The distribution of temperature zones in Figure I is not arbitrary, but is based on years of experimentation with various composting processes.

Figure I
Temperature Zones in Microbiological Decomposition

Zone	Temperature	Microorganism Types	Decomposition Zone	Hygienic Classification
I	under 45°C	Mesophilic organisms	oligothermic ("cold fermentation")	full virulence
II	45°-55°C	Transition from mesophilic to thermophilic organisms	beta-mesothermic	biochemical decontamination
III	55°-65°C	Thermophilic organisms	alpha-mesothermic	biophysical decontamination
IV	65°-over 80°C	Fading of thermophilic organisms; start of chemical processes	polythermic ("hot fermentation")	thermal disinfection

Precise and easily understood terms for all processes of disposal and utilization of town refuse, including the introduction of standard nomenclature, was urgently demanded at the First International Congress on "Disposal and Utilization of Town Refuse," Scheveningen, the Netherlands (1959). With it many disagreements and misunderstandings should be eliminated.

When individual decomposition zones are labelled oligo-, meso- and polythermic, it is not said that temperature is the only determining factor in all of these zones, but that there is also a complex process within the composting material which relates directly to temperature changes.

Because the solution of the hygienic problems during processing of town refuse is the primary factor, all secondary problems can only be solved after the material is completely decontaminated. Although the final use of the material might determine which decomposition process of the material and which decay- or ripeness-grade it must have before it is passed on, a uniform nomenclature must yet be set up for these concepts. A minimum hygienic requirement must be observed in all cases regardless of the final usage; whether only for spreading, filling and maturing; or for agricultural or technical purposes. What is this minimum requirement and how can it be reached?

One can speak in this connection about a so-called two-phase composting, that is, a must-decay and an optional-decay. The must-decay corresponds to the hygienic phase of composting and runs, dependent on the material, to that point at which there are no hygienic reservations about further utilization. The second phase is more or less a need-decay, determined by the usage of the compost material. Further information about the decay processes is found in another place of this IRGR bulletin.

We shall now examine the hygienic phase which will interest the practitioner as to the measures he must take to satisfy the hygienic requirements. An attempt was made to express the hygienic phase in various diagrams and to construct from them a pattern which would be roughly applicable for all materials. Naturally, during all composting processes, one must remember that the content of the individual components of refuse and sludge, the water, the C/N ratio, aeration conditions, etc., each play a large role. But all these biological, physical and chemical processes during composting mirror themselves finally in the temperature curves. If, for example, optimum aeration conditions do not exist, the temperature will rise only to a certain maximum. It is similar with the moisture content. I believe it is therefore not logical when one disregards all these things and simply tries to set up a pattern from practical experience in which all processes fulfilling the hygienic requirements may be put. On the other hand, this pattern makes it possible to adapt the respective processes to the hygienic requirements as well as to individual wishes; for example, one can eliminate the polythermic decomposition zone and take instead a longer beta-mesothermic decay zone or vice versa.

Figures 2 and 3 show that there are differences in the various non-sporeforming pathogens of the salmonella group as to survival time in the individual decomposition zones.

In the decay diagram (fig. 2), test strains of Salmonella paratyphi B and S. typhi are opposed. This was a check on non-sporeforming pathogenic bacteria as placed in sealed ampoules into composting material and as inoculated directly into the raw material. It was therefore possible to compare the influence of purely thermal reaction on the sealed ampoules and the total effect of antagonistic processes on the directly-inoculated infectious agent. It is clear from the graphs that the effect of the complex antagonistic process is marked by a much shorter survival of the pathogenic bacteria in the various decay zones, whereas thermal destruction of salmonella sealed in ampoules requires a longer period of time.

In the zone below 45°C certain destruction of all salmonella strains cannot be assured. At a decomposition temperature of 45°C typhoid bacteria were destroyed in the natural material after 79 days and in the ampoules after 189 days, whereas paratyphi B bacteria survived in ampoules up to 257 days and resisted the complex antagonistic processes in composting material 247 days.

Figure 2
Decontamination of Household Refuse
Non-sporeforming Bacteria
Biological Decay Diagrams with Salmonella Destruction Zones
Test Species:

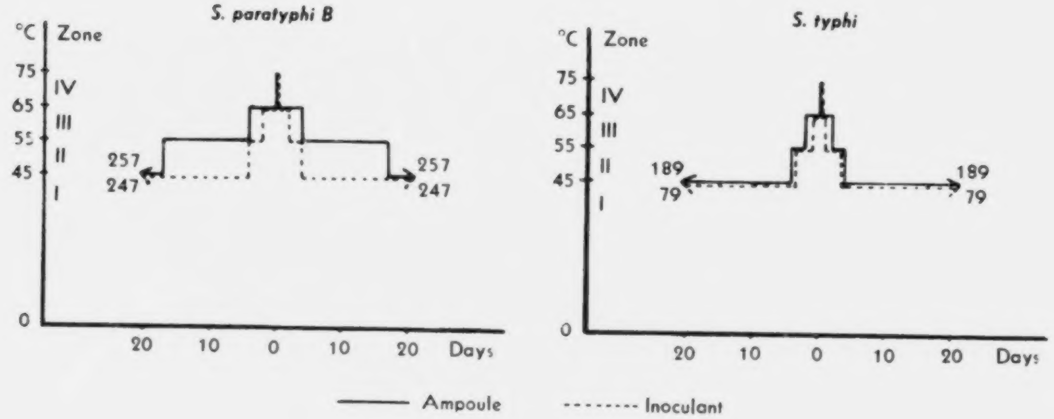
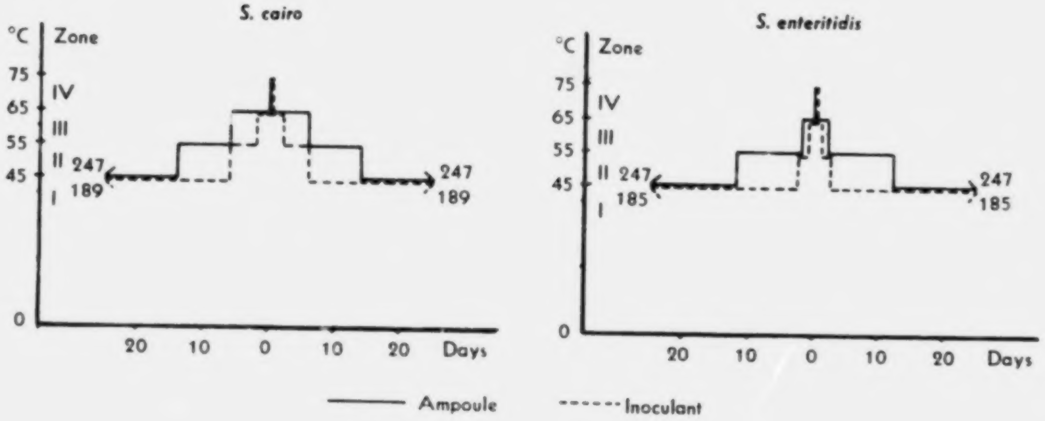


Figure 3
Decontamination of Household Refuse
Non-sporeforming Bacteria
Biological Decay Diagrams with Salmonella Destruction Zones
Test Species:



The differences between *S. paratyphi B* and *S. typhi* are clearly shown in the beta-mesothermic decay zone II. Destruction of typhoid bacteria in ampoules occurred after four days, whereas it took 17 days with paratyphoid B bacteria. Destruction periods were much shorter in the material and were about equal by bacteria types; within four days both paratyphoid B and typhoid bacteria were eliminated. Both salmonella types were destroyed within one day in the polythermic zone without regard to whether in ampoules or not.

The decay diagrams of the two test strains *S. cairo* and *S. enteritidis* (Fig. 3) correspond to the other salmonella types. There is no sure destruction of the test strains in zone I. At 45°C *S. cairo* and *S. enteritidis* in ampoules survived 247 days. Exposed to a natural decay environment, *S. cairo* survived 189 days and *S. enteritidis* 185 days at 45°C. In decay zone II ampoule-enclosed salmonella survived 14 days (*S. cairo*) and 12 days (*S. enteritidis*). In natural compost environment, *S. cairo* was destroyed after six days and *S. enteritidis* after two and one-half days.

In decay zone III, ampoule-encased salmonella of type *S. cairo* survived six days, that of type *S. enteritidis* two days; in the natural environment *S. enteritidis* was killed, as was *S. typhi*, during the first day while *S. cairo* survived two days.

Without regard to strain, all ampoule-encased and free salmonella were destroyed within a day in the polythermic decay zone.

It is natural to assume that the polythermic decay zone and all hotter zones disinfect solely because the limit of protein destruction has been passed. But these zones are not wanted in agricultural use of the compost because high temperatures cause a one-sided shift of the CN-ratio and practically result in a burned product which lowers the agricultural value. Consequently, the mesothermic decomposition zone will commonly be preferred.

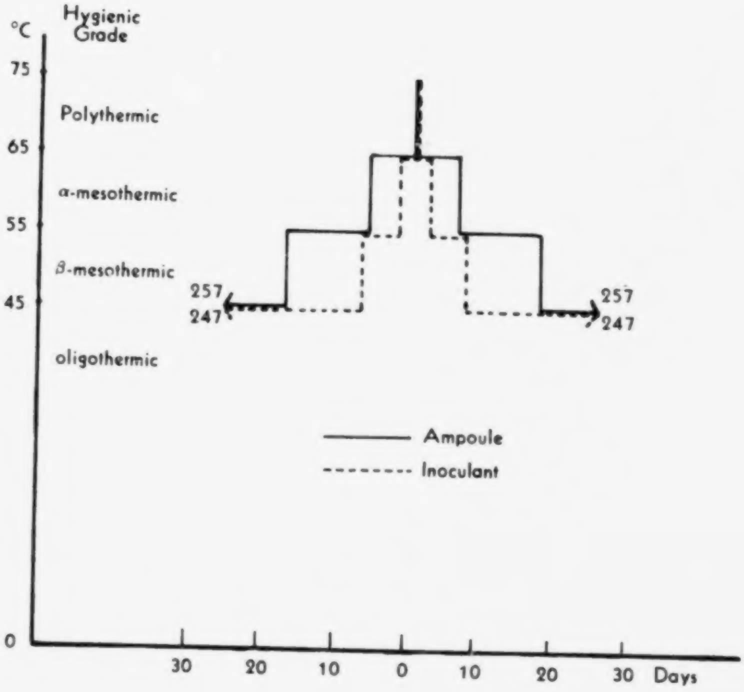
If the survival diagrams of the non-sporeforming pathogens of the relatively sensitive bacteria *S. typhi* and the resistant paratyphoid bacteria are combined as to duration in the various temperature zones, the following graph results which shows the hygienic phase of composting to be followed if a hygienically good product is to be produced (Fig. 4).

This grade index for refuse and refuse-sludge mixtures which was set up for decontamination of town refuse relating to salmonella destruction shows only the following:

No sure destruction of salmonella is achieved in the oligothermic decay zone, under 45°C.

At a decomposition temperature of 45°C, salmonella survive 247 days. If the salmonella are sealed against the antagonistic processes of decay, at least 257 days are necessary for their destruction.

Figure 4
Decontamination of Household Refuse
Refuse and Refuse-Sludge Mixtures
Hygienic Grade Index for Salmonella



In the beta-mesothermic decay zone, 17 days are needed to destroy salmonella if only temperature acts on them, but those subject to microbial antagonisms are destroyed in seven days.

In the alpha-mesothermic decay zone, exposed salmonella are destroyed within two days, while sealed bacteria survive six days.

In composting, if all parts of the raw material reach more than 65°C in the polythermic decay zone, decontamination of the material can be counted on within one day.

All processes fulfill the hygienic requirement for sufficient processing of town wastes if the temperature curve of all the material can be projected within the reach of this hygienic grade index. The hygienic requirements are fulfilled in this case and further processing of the material would be left up to the wishes of the user.

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2. Plant Pathology Problems in Refuse Composting by Dr. P. Martin (Institut für Phytopathologie der Justus Liebig Universität, Giessen).

Disease organisms of cultured plants can enter the refuse with vegetable and potato wastes from the kitchen, or with garden wastes. In view of a possible spread of such germs by refuse compost, it is important to study the influence of composting on these bacteria and to know what composting processes assure complete destruction of the pathogens. Not only is survival duration of plant pathogens of importance, but also the extent that refuse compost acts to hinder or to help disease germs in the soil. One must also ask if the disease tendency in the crop plants is influenced by the application of refuse compost.

A special danger in the use of refuse compost is formed by those disease germs which could permanently contaminate the soil. In repeated plantings of a susceptible crop, a heavy increase of the particular disease organism could occur. One speaks in this case, of a successive crop disease. In relation to such diseases, special attention must be focused upon all vegetables and potatoes because scraps from these plants are frequently found in refuse.

In the following, the most important disease organisms are listed and their possible significance briefly described. If experimental results are available, they are listed.

An important successive crop disease of vegetables is Plasmodiophora brassicae, cabbage hernia. The results of experiments on survival rate of spores of this fungus are discussed at the end of this article. The organism attacks the roots. Thick spots, like fingers or clumps, are formed and are filled with numerous resistant spores. They can contaminate the soil for 4-6 years. Spore germination depends on the acidity of the soil. It occurs only in acid areas so that effective control can be obtained by application of lime. It should be checked if alkaline compost does not provide similar favorable control.

Another successive crop disease of cabbage is Olpidium brassicae, which also harms lettuce and a few other plants. The spores are also active in the soil for a long time. It was recently discovered that olpidium can transmit a viral disease in lettuce. The disease appears as a lightening of the leaf veins occurring about six weeks after seeding. The connection between Olpidium brassicae and the virus seems to be very close, so that this might be used as an accurate and simple test for survival of olpidium spores. Given that the fungus attacks the roots, and that the disease is not easily detected -- it is almost impossible to isolate it -- one may deduce its presence or absence by the occurance of the virus. The first trial with this fungus at the Dano plant in Bad Kreuznach showed that the virus did not occur in a lettuce test after a rapid composting process at 70° - 80°C. (In the case of a possible pure temperature effect, one must consider that viruses can be destroyed by temperatures which host cells survive.) Plasmodiophora brassicae and Olpidium brassicae cannot be grown on artificial nutrients; therefore work with these pathogens presents difficulties.

In a root-killing disease of potatoes, Rhizoctonia solani, black-brown spots occur on the potatoes as one of the symptoms. These are sclerotic, durable organisms, which are relatively resistant and could survive refuse composting. (This fungus also occurs in many soils.) In early preliminary experiments, potato pieces with sclerosis were placed in compost windrows. They were removed after one month and disinfected externally. Then they were placed on malt agar. In contrast with control experiments, there was no disease development. The sclerosis apparently did not survive even a short composting period at higher temperatures (at times over 67°C).

Bacteria can also be spread through refuse, i.e. refuse compost. One thinks of such diseases as black vein of cabbage, fatty spots of beans, lettuce decay, tomato wilt, etc. However, it is not necessary to examine the phytopathogenic bacteria separately. The results with salmonella (see Knoll) can be transposed to the causes of plant diseases without reservation. Spore-forming bacteria are not known as phytopathogenic parasites.

Pathogenic plant viruses could also cause soil contamination through refuse compost. In this regard, one must consider those viruses that can survive in the soil and could infect plants through the roots. For example, the tobacco mosaic virus is very resistant and survives even the fermentation during tobacco processing. The virus survives up to 150°C in dry leaves. It is very resistant to chemicals and other factors. It remains active for long period on live and dead plant particles in the soil.

Animal pests that can cause crop damage are nematodes. The cyst-causing Heterodera rostochiensis is very important in connection with refuse composting. It causes heavy damage in potatoes. Results with these cysts are available from Holland which may prove to be insufficient (1). The

Pile Experiment on Survival Ability of *Plasmodiophora brassicae* Spores

	Storage, Days	Attacked Plants, * %	Temperatures up to removal from the piles: Median value, °C	Temperatures up to removal from the piles: Maximum and Minimum, °C
Pile 1**				
Inserted sample	20	1.8	37.3	16 - 45
Control	20	1.9		
Inserted sample	49	1.7	32.5	15 - 40
Control	49	24.0		
Inserted sample	70	0.0	31.3	14 - 38
Control	70	76.0		
Inserted sample	105	18.0	30.5	14 - 42
Control	105	13.0		
Inserted sample	132	63.0	27.6	12 - 41
Control	132	93.0		
Pile 2**				
Inserted sample	253	4.0	27.3	10 - 47
" "	253	4.3	28.3	13 - 43
" "	253	0.0	25.3	7 - 41
" "	253	0.0	25.6	8 - 42
" "	253	0.0	26.9	5 - 41
Control	253	37.0		

* The occurrence was counted on 6-week old cabbage plants (greenhouse test).

** Pile composition: Shredded refuse-old refuse-sewage sludge 4:1:1 (Pile 1) and 2:1:1 (Pile 2).

cysts were placed in containers and buried in compost piles. The temperature of the piles was 50-55°C. After three months, the cysts were treated with juice from potato roots to cause the larvae to emerge. Only those cysts stored at room temperature survived.

According to van der Laan (2), normal compost restricts the attack of *Heterodera rostochiensis* on potatoes. It is supposed that the physiological resistance of the plants is increased.

Experiments with Plasmodiophora brassicae:

During 1960-61 Scheinpflug conducted experiments at this institute on the survival ability of *Plasmodiophora brassicae* in low temperature composting.

Spore suspensions (10^6 spores/gram refuse) or shredded cabbage hernia growth were mixed with the raw refuse. This refuse was placed in porous bags in the windrows. As a control, containers with one part of the same refuse and two parts of a 1:1 sand-peat mixture were placed in the open air. For the evaluation, the refuse compost was then mixed with sand and peat, and placed in flower pots. Each pot was sown with 25-30 cauliflower seeds. Counting of diseased plants was done after 2-3 months.

The table shows that germinating plasmodiophora spores were present at all removal times. There is a considerable spread in the values, as there was only a limited amount of material in the bags and part of the plants died during cultivation. This occurred even in the controls. Starting after 253 days (pile 2) there appeared a decrease in germination ability. It is clearly shown in this experiment that pile composting at low temperatures (maximum temperature: 46.5°C) is not sufficient to destroy plasmodiophora spores.

Destruction can be reached if the piles are so made that higher temperatures are achieved. In piles with a temperature between 60° and 67°C there were no germinating spores in eight samples after 21 days.

Such complete destruction was also achieved in the rapid composting process with the Dano plant at Bad Kreuznach. Temperatures in the drum during the seven-day process were 70°-80°C. It can be assumed here that the killing of the spores was due primarily to the temperature effect. These experiments only partially answered the questions posed in the beginning. Further experiments are needed to obtain a clear picture as to the reaction of phytopathogenic disease agents to various composting processes and the effect of refuse compost on parasites and host plants.

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3. Mold Fungi and Refuse by Dr. A. von Klopotek (Institut für landwirtschaftliche Mikrobiologie der Justus Liebig-Universität, Giessen. Director: Prof.-Dr. H. Glathe).

The action and appearance of mold fungi during the composting of refuse and refuse-sludge mixtures was examined during the last year at the Institut für landwertschaftliche Mikrobiologie in Giessen. This is of general interest and expressions such as "fungal zones" or "actinomycetes zones" in the pile are common among practitioners. The expression "well-mildewed" is even used in advertisements to express the quality of a material. Results of these experiments have been reported by Straub and Glatne (1961), and von Klopotek (1962). In 1961 and 1962 the experiments were continued and, at this time, repeated as to the effect of various promoting agents in the refuse and sludge in windrow composting.

It was observed that the influence of promoting agents on development of fungi in the piles was negligible. The refuse varied so greatly in its composition, moisture content, and the speed of heat development and cooling that these factors influence the biological processes much more than any promoting agent. It was observed in the experiments of the last two years that it is difficult to obtain comparable results of associated microflora due to the composition of the refuse.

Piles from Baden-Baden were compared with piles from Bad Kreuznach. The germ content of mesophilic fungi was a minimum of 16,000 organisms per gram of material in Kreuznach, while the highest recorded in Baden-Baden was 10.0 million per gram of material for fresh refuse.

In earlier experiments (Table 1), it was noted that fungi increased rapidly with increasing temperatures up to about 37°C. In Baden-Baden they were still more numerous at temperatures of 64°-65°C than at the start, but by 67°C they had disappeared. With increasing temperature, there was also a change in composition of flora: Geotrichum increased up to 45°C, at 55°C the flora was exclusively Cladosporium.

TABLE 1
Fungi Cell Counts at Increasing Temperatures
millions/gram material

Temperature	Baden-Baden	Bad Kreuznach 1961	Heidelberg 1962
Starting material	3.17	0.016	2.30
37°C	27.30	0.0013	-
45°C	6.00	0.0003	2.50
55°C	5.00	-	0.02
64°C	8.00	0.0	-
65°C	3.70	-	0.0
67°C	0.0	-	-

In Table 1 the cell counts at Baden-Baden are compared with those of the last two years.

In Heidelberg (1962) the first sample was obtained at 45°C, and at this stage the germ count was higher than at the start. At 55°C there was a marked decrease in germs. The explanation lies in the examination of types of flora in the pile. In Heidelberg material, there was no Cladosporium; at 45°C, 80 percent of the flora content was Geotrichum, and 20 percent was Mucorineen, both of which, as is known from earlier experiments, cannot stand temperatures above 55°C. It is therefore possible to explain the rapid decrease in germ count by the different composition of flora.

In was entirely different in the Bad Kreuznach experiment (1961). In this case the count decreased with the start of heating. This again does not prepresent a genuine contradiction of earlier observations but lies in the material composition. The "raw refuse" from Bad Kreuznach was pre-fermented in the Dano drum, and had already experienced the first heating; it contained relatively few fungi, but a varied flora, the usual 70 percent of Geotrichum, which caused the sharp increase at Baden-Baden at 37°C, was only 10 percent and, besides that, over 19 different species (against 6 usually in other raw refuse) were isolated. Besides the usual fungi, 20,000 yeast cells per gram of material were found (Rhodotorula mucilaginosa, Debaryomyces kloeckeri, Candida parapsilosis). In all other cases yeast was isolated only occasionally; e.g., Debaryomyces in Baden-Baden (1962, 2nd turning).

Still different conditions were found in 1962 in the Kreuznach material that was used in experiments on promoting agents. It contained only one species of Penicillium, 0.4 million germs per gram of material. This fungus appeared during germ evaluation only after a dilution of 10^{-5}, and it was shown to be inhibited by a bacterial agent. This inhibition decreased with increasing dilution so that the penicillin organism could develop itself. It is thought that the same bacterial agent prevented the growth of other fungi. We found, thus far, that the thermophilic species Thermomyces and Aspergillus are not inhibited.

These are only a few examples of the wide variations that can occur in the fungi of a composting pile.

One question remaining unanswered in earlier experiments was: from where do the fungi come that reoccupy a pile after cooling? It was suggested that this occurs from the edges of the piles. A cross-section was made on a pile in Heidelberg (1962) to test this idea. Samples were removed from the pile at 30 cm. intervals from top to base during every turning of the pile. These samples were separately examined. The germ counts of Table 2 clearly show that fungi are always present in the outer layers and that fungi counts increase with cooling, but still at relatively high temperatures. (In Table 2, numbers marked with + indicate maximum temperatures.) The invasion of fungi into the center of the pile is very noticeable after the third turning.

TABLE 2

Pile Cross-Section, Heidelberg, 1962

Mesophilic fungi/gram of dry material

Sampling Point, cm. from base	First Turning	Second Turning	Third Turning	Between Samples	Final
Outer layer	1,200,000	359,000	82,000	1,934,000	8,860,000
120-150	63,000	1,590	1,160	5,510	380,000
90-120	0+	0	160+	2,590	107,000
60-90	0	0+	0	2,650+	3,500
30-60	0	0	0	4,380	970+
0-30	7,680	0	1,000	2,710	1,900
Temperatures:	64-71°C+	52-68°C+	46-47°C+	54-62°C+	32-56°C+
Time:	2 weeks	4 weeks	7 weeks	14 weeks	21 weeks

The germ counts at the demolition of the pile (final), after undisturbed storage for 14 weeks, is less a prime example of gradual penetration of fungi but rather proof of its dependency upon oxygen. The counts are reduced in the oxygen-poor zones of the center compared with the between samples, whereas they increase at the pile base.

Final samples in the experiments on promoting agents showed a wide variation in fungi content independent of the addition of nutrients. Two piles in Bad Kreuznach (1961) which were exposed to the same environment, both with a moisture content of 15 percent, had in their centers in one case 50 and in the other four million fungi per gram of material.

Thermophilic fungi were more dependable in their appearance. Generally, they do not increase during heating and appear later during cooling than mesophilic fungi; then, however, they increase rapidly, especially in dry well-ventilated zones of the pile. The fungal zones which are recognizable in a pile cross-section, contain thermophilic fungi as a rule. Only in isolated cases are actinomycetes formed in large numbers in these zones.

To the 1962 list of 106 species of fungi isolated from refuse can be added 19 species of fungi:

Ascochyta sp.
Aspergillus nidulans
Aspergillus niveus
Aspergillus terreus
Calcarisporium arbuscula
Chaetomidium
Chaetophoma
Circinella nigra
Circinella simplex
Graphium bulbicola
Pestalotia
Phialophora sp. I
Phialophora sp. II
Pleospora herbarum
Pyrenochaeta acicola
Pythium anandrum
Scolecobasidium
Sporotrichum chlorinum
Sporotrichum sp.
(thermophilic species)

The results show that the appearance of fungi in compost piles is heavily dependent on the material, the moisture content and the temperature. The formation of "fungal zones" is caused by the large increase in thermophilic fungi and the zones are marked by initial cooling and good aeration. In dry piles they also appear throughout the entire pile cross-section.

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4. Effect of Municipal Composts on Numerical Development of Azotobacteria

by Dr. E. Ahrens (Institut für landwirtschaftliche Mikrobiologie der Justus Liebig-Universität, Giessen. Director: Prof.-Dr. H. Glathe).

It appeared to be appropriate to check the effect of municipal composts upon azotobacteria more closely since on one hand Ruschmann (3) found that azotobacteria completely disappear from the soil after the addition of only 40 dz/ha (ed. note: given as such; probably 8,000 kg/hectare), and on the other hand Pfeiffer (2) added these organisms to his starter preparation.

Azotobacterium is non-sporeforming. How this organism reacts to higher temperature was therefore first examined. The following results were obtained:

Medium	H_2O %	Development Time	Destruction Temperature for azotobacteria
Nutrient agar	-	1 minute	53°C
Compost	24.5	1 minute	54°C
Soil	16.7	8 hours	50°C

Azotobacteria could not be isolated three days after inoculation during pile composting (peak temperature 64°C during this time). The results, therefore, show that an addition of azotobacteria to municipal compost is purposeless, at least in the beginning.

Another question was how azotobacteria act in the material when the optimum temperature is maintained for these organisms. The result of such an inoculation experiment is given in Table 1.

The counts show that the composts acted vary differently on azotobacteria. In all samples with origin A, the organisms increased, even though in differing quantities. In samples with origins B and C, the organisms were more or less rapidly destroyed. Earlier investigations (Ahrens (1)) with other samples showed that azotobacteria cannot maintain themselves, especially in non-decomposed material. For this reason, various decay times were checked in this experiment. There is no regularity noticed between decay duration and hindering or promoting action. However, since samples using the same starting material acted very differently on azotobacteria, a certain connection between the results and decay time or decay process cannot be considered eliminated. But the problem must be more complex than first assumed. In any case, the negative effect of compost B and C on azotobacteria is unsolved for the moment. The sludge mixed in compost B is very probably not responsible for the hindrance since sample C without sewage sludge acted in the same way.

A further experiment should give information as to eventual changes in the hindrance characteristics after longer composting. Such an experiment was done in that a part of sample of origin B, which had undergone a pile composting of 28 days and had acted strongly inhibitory to the trial inoculation, was held 18 weeks in the laboratory at 25°C, while another part of the same material was stored in dry air during this time. The samples then received the same amount of water and the same inoculation of azotobacteria. The results of this experiment are shown in Table 2.

TABLE I

Action of Azotobacteria in Various Municipal Composts

(Container experiment, temperature 25°C)

Inoculating material; azotobacteria-lime

Koch method

Origin	Pile Composting, Days	pH at Start	Count of cells in 1 g dry substance Examination after ___ days					pH at End
			0	10	33	54	118	
A Without sludge;	0	7.95	2,121	5,954	18,341	48,800	10,400	7.95
Composting	14	8.20	2,326	27,409	9,136	6,645	34,883	8.30
Started	29	8.15	2,614	89,870	35,947	65,359	84,150	8.30
6/5/1962	51	8.35	2,508	96,581	64,103	41,026	57,189	8.30
	102	8.25	2,761	10,940	2,150	2,600	2,100	8.15
B With sludge;	0	7.90	2,560	5,460	175	210	35	8.05
Composting	15	7.95	2,390	480	0	0	0	7.90
Started	28	8.00	1,850	400	0	0	0	8.20
5/29/1962	50	8.05	2,500	1,600	900	180	14	8.00
	98	8.15	1,980	1,730	300	300	37	8.00
C Without sludge; summer 1959	0	8.15	3,580	2,800	680	730	54	8.20

TABLE 2

Effect of Post-decay of Refuse-Sludge Compost at 25°C on the Inhibition of Azotobacteria

Inoculant: diluted azotobacteria pure culture Koch method

No.	Pile Composting (weeks)	Post-decay in laboratory (weeks)	Examination after days					
			0			9	18	
			Azotobacteria/gram dry substance					
			pH	Absolute	Rel.	Rel.	Rel.	pH
1	4	0	7.70	174,000	100	120	39	7.70
2	4	18	7.70	153,000	100	8	0.9	7.70

The counts show that the number of azotobacterial cells in both samples was reduced, but the reduction was much slower in the post-composted material than in the air-dried material. One can deduce from this that inhibitory materials for azotobacteria might disappear after a longer decomposition. It was observed that the post-composted sample did not mildew, whereas the air-dried sample was completely covered by fungi.

How the above samples act against azotobacteria in the soil was also examined. A Göttinger soluble clay was used from the vicinity of a former power station. It had a relatively high azotobacterial count, very high phosphoric acid content, and exhibited good buffer characteristics. The soil was collected in 500g samples which were placed in 750 ml containers. The samples were then mixed with various composts, moistened, and incubated at 25°C. Table 3 contains the results of this experiment. They show that all samples of origin A and C stimulated the azotobacteria to rapid growth whereas in samples of origin B this happened only in one case. In the others there was even a considerable reduction in cell count at times. In general the results of the fertilization experiment indicate a certain agreement with the results of the inoculation experiment. The exception of one sample of origin A and one of sample C cannot be immediately explained. In both cases it appears that the suspected inhibitory materials were rapidly made ineffective after mixing the materials with soil.

Further attempt was made to show the inhibitory agent in water extracts of compost. The extracts were made from a compost-water ratio of 1:20 after several stirring and settling periods. Their effect on azotobacteria was checked in soil after various reaction times. In this case the majority of samples from origin A promoted, and from origin B and C

TABLE 3

Behavior of Azotobacteria after Fertilization of Göttinger Clay-loess with Various Municipal Composts

Container experiment, temperature 25°C

Fertilizer amount: uniform per sample, 100T/ha organic substance (volatile matter)

Koch method

Compost samples		Initial Soil Test		Count of azotobacteria cells in 1 g dry substance Examination after ____ days			
Origin	Pile Composting, Days	pH	H_2O%	0	9	28	107
Unfertilized	---	7.4	16.8	6,370	7,732	5,769	10,817
A	0	7.4	17.9	6,060	24,800	45,200	31,700
Without sludge;	14	7.4	17.9	6,330	46,300	85,300	167,500
composting	29	7.4	17.3	5,410	13,700	41,700	38,700
started.	51	7.4	17.6	6,370	27,500	46,700	120,100
6/5/1962	102	7.4	17.3	5,710	27,400	64,100	146,900
B	0	7.4	17.4	5,960	6,700	6,700	4,240
With sludge;	15	7.4	17.0	5,390	6,600	5,400	5,180
composting	28	7.4	16.6	5,430	7,000	79,100	45,000
started:	50	7.4	17.0	6,630	6,500	10,000	1,200
5/29/1962	98	7.4	16.7	7,080	6,000	5,700	1,320
C Without sludge; summer 1959	0	7.4	17.4	5,990	25,400	42,400	55,700

hindered, the bacterial growth. However, the results were not always uniform so that the present method of determining possible inhibitory material is not satisfactory. One must search farther for new methods.

It is know from the literature that very different organic residues, for presently unknown reasons, can be inhibitory to microorganisms. Our investigations by prolonged fertilization experiments and in the laboratory came to the same conclusion. A fertilization with green rape leaves in a laboratory experiment reduced azotobacteria counts from about 8,000 cells 3- to 4- fold. It is recognizable from these results that inhibitory action is not a specific characteristic of compost from town refuse. (In connection with this, see reference Winter and Schoenbeck (4)). The nature of these materials is not sufficiently explained to date. Probably they are various organic compounds. Certain decomposition products and phenol compounds are mentioned. Phenols could be present in the plants and antibacterial decomposition products could be produced during decay under certain conditions. In addition, there could be antibiotic agents in unprocessed town wastes. It is important that the cause of some confirmed cases of inhibitory action be further explained. Previous experience indicates that the antibacterial effect of organic materials appears only under certain conditions. For this reason, it is necessary to check the various environmental requirements of the microorganisms.

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5. Experiments on the Effect of Various Additives on Windrow Composting of Refuse and Sludge by Dr. G. Farkasdi (Institut für landwirtschaftliche Mikrobiologie der Justus Liebig-Universität, Giessen. Director: Prof.-Dr. H. Glathe).

Composting is a biologically-and chemically-influenced process which occurs spontaneously in nature since suitable microorganisms are normally available in sufficient quantity. During commercial composting one must always see that favorable environmental conditions are created for those microorganisms responsible for the decomposition.

Compost plants are attempting to speed up the decomposition process because of economy and, in many cases, lack of space. One possibility is to inoculate the composting material with certain additives. It is generally understood that the additivies are to guide the decomposition in the desired direction.

It is possible to classify these additives into two main groups:

One group may be termed strictly accelerating agents which are supposed to stimulate the action of decay organisms present in the compost. They consist of a mixture of organic and inorganic ingredients. They can also contain microorganisms as they are not sterilized; however, the effect does not depend on these but on the biostimulants contained in the preparation.

The other group is the so-called inoculation agent which contains a concentration of certain microorganisms. The composting is supposed to be accelerated or guided in the proper direction by the influence of these cultures. There are two types of inoculating agents:

1. The so-called "compost starter" is an inoculation preparation which is mixed with the raw material to accelerate the decomposition;

2. Inoculating material which is added after the strongest decomposition, that is after the peak temperatures have passed. These are to increase the humus materials and other valuable components in the end product.

In practice, inoculation plays a certain role in processes, as in some (i.e. Multibacto), it is a part of the process, and in others it is recommended for acceleration of the decomposition or for improvement of the end product.

The effect of additives has generally been shown to be negative by competent experts. Gotaas (1), Golueke (2), Wylie (3), Burman (4), Straub (5), and Weststrate (6) all express the opinion that refuse and sewage sludge contain several billion extremely varied microorganisms. Some of these become active and multiply and others die out depending entirely upon the physical and biochemical conditions present in the particular environment. Added cultures can only take over when environmental conditions do not favor the original organisms and help the inoculated cultures.

Pfeiffer (7) emphatically endorses the inoculation of composts with bacteria, particularly recommending the use of B.D.-starter which he developed.

Spyra and Glas (8) reported some success in experiments they conducted in 1957-8 with "Edafil." In composting garden wastes they achieved better decomposition of cellulose in inoculated heaps in regard to time and quantity. Small plot trials with the compost brought neither a sure increase in harvest nor quality improvement, but a steadier growth and more intensive chlorophyll formation was observed.

In preliminary experiments of the Giessen University research group at the compost plant at Heidelberg (9), some results were noted after inoculation of ground raw refuse with Edafil. The material in the inoculated piles was more thoroughly decomposed and had finer particles and a darker color. In an associated vegetation experiment with red beets in Mitscherlich containers, a statistically significant increase in yield was noted with compost of fresh refuse that was inoculated with Edafil over that not inoculated.

In order that the present contradictory data could be checked and to enable us to give a composting plant a scientific recommendation, it was decided to test the effectiveness of the known materials for inoculation and acceleration. In this test only the question regarding the preparation speeding up the decay in commercial windrow composting was to be examined. The examination of effectiveness of certain inoculation materials in certain fermentation cell processes (such as the Earp-Thomas Multibacto) could not be made due to lack of suitable equipment. These experiments are to be done later.

During these experiments, determination of any possible effect on the quality of the end product was consciously avoided because suitable methods were lacking to test this accurately and also because this question is not of special importance in the general production of refuse-sludge composts. The current trend is to decompose the compost only to the extent that will insure an unquestionable hygienic condition. Exceptions to this are plants primarily producing for gardens and special plantings. In this early stage of decomposition, it is probable that the expected nutrients are not yet formed; that is their existence cannot be proved.

The experiments were conducted by the research group at Giessen Univeristy Institute during 1961 and 1962.

The following three materials, considered as accelerating agents were used in the 1961 experiments:

1. "Edafil," a soil inoculant, which contains, according to the producers, a certain amount of nutrients and a mixture of microorganisms in a dry state that are activated by light and water to form nutrients.

2. "Proteg Oleo," a mineral oil derivative, which is supposed to contain a certain percentage of ether-extractable oils and plant-extractable materials.

3. "Zusätze-Frankfurt." This preparation is not commercially available and is used exclusively at the Frankfurt compost plant. It contains ground rock (rock flour), yeast wastes, and diluted mineral oil.

In the 1962 experiment, two typical compost starters were examined.

1. "Multibacto (Earp-Thomas Preparation No. 1).

2. "B. D.-Starter" according to Pfeiffer.

Both of these preparations contain mixed cultures of particular microorganisms, not more closely defined, and are supposed to act favorably on the decomposition process.

The aim of this study was to examine, if possible, the effect of these additives in all types of windrow composting: composting without grinding (Baden-Baden system), composting with grinding (Rasping method, Door-Oliver in Heidelberg), and windrow composting following pre-composting in a digester (Dano process in Bad Kreuznach). All the piles consisted of refuse-raw sludge mixtures except in Heidelberg, where they consisted only of rasped raw refuse.

The experimental windrows were 1.5 m. high, 2.0 m. wide, and 5.0 m. long. Two parallel windrows were treated with the same additive. The piles were constructed in layers with the appropriate amount of additives which were suspended in water, evenly mixed into the piles. The control piles received an equivalent amount of chlorine-free water.

In the first year, specially-prepared samples of refuse were put in porous plastic bags and placed in the middle of the piles. These samples were for subsequent examination and were separated as to pathogenic and nonpathogenic content. At each placement, a thermocouple for temperature measurements and plastic tube for gas samples were installed. Temperatures were measured daily with resistance thermometers; gas analyses (CO_2 and O_2) were made with an Orsat apparatus.

Piles were turned during the 3rd, 6th and 9th weeks, and were dismantled after about 14 weeks of composting. Samples were taken for examination after each turning and after completion.

In the 1962 experiments, piles were turned during the 2nd, 4th, and 7th weeks, and dismantled after about 14 weeks. There were no samples prepared for non-pathogenic examinations and the material was taken directly from the piles according to a uniform system.

The hygienic examinations were made for the reason that an intensification of decay might result in a faster destruction of disease organisms. Various physical, chemical and biological tests as well as notation of external characteristics such as color, structure, odor, etc. were made to assure the complete evaluation of possible effects from these additives. The physical tests were for temperature, reaction (pH), and particle size. The chemical tests were for carbon dioxide, oxygen, water, and ash content, as well as volatile solids and ammonia content. The microbiological tests included the determination of total germ counts and self-heating capacity.

Everything was done to note any indication of effect of the additives. Not only was the temperature development of the treated and untreated piles compared, but the speed of temperature rise, maximum temperatures, duration above 65°C, and reheating after the third turning, were also compared. Similar comparisons were made with the results from the gas and sieve analyses.

It is not possible to present the extensive data in detail in this short paper (a later publication is planned). A few typical examples taken at random from the many examinations will be shown as representative. These are to illustrate and prove the conclusions drawn from the experiments. We emphasize that these examples were selected completely impartially and that others not shown here are equally negative.

To indicate the results of 1961, we will use the speed of temperature rise (initial faster and more intensive decay causes faster and higher rises in temperature) and ammonia content (more intensive decomposition converts more organically-bound nitrogen into ammonia which is then fixed by a part of the microorganisms).

As can be seen from Table 1, the differences between individual measuring points in the same pile, and also in parallel piles, were much larger than the differences between the treated and the control piles. The trend also varied in different localities; for example, the control piles in Bad Kreuznach had the lowest median temperature after 7 days, whereas in Baden-Baden they had the second highest median temperature after 7 days.

The crossing of the 55°C temperature value always occurred with the insignificant variation of one day. The only greater difference of two days, Proteg Oleo in Baden-Baden, occurred between two piles treated in exactly the same way.

It must be concluded from all this that the variations between individual piles, cannot be attributed to the effect of the accelerating agents.

In the experiments at Bad Kreuznach, it seems that one would have to attribute a certain effect to Proteg Oleo: intensive development at the start, heaviest fixation after 6-9 weeks, and lowest content at the end of the experiment. The results of the Baden-Baden test do not confirm this tendency.

The relationships are not very different in the 1962 experiments. Some examples are shown in a few temperature values.

TABLE 1

Speed of Temperature Rise

(measured in °C on the 7th day)

	Baden-Baden			Bad Kreuznach		
	MP 1	MP 2	Mv	MP 1	MP 2	Mv
Edafil I	66.0	68.5	67.0	68.0	65.0	67.3
Edafil II	64.5	68.0		*	69.0	
Proteg Oleo I	62.0	63.5	66.5	68.0	*	66.6
Proteg Oleo II	68.5	72.0		63.0	69.0	
Zusätze-Frankfurt I	72.5	73.5	72.5	65.0	*	66.3
Zusätze-Frankfurt II	72.5	72.0		65.0	69.0	
Control I	65.0	69.0	69.0	*	70.0	64.0
Control II	70.0	71.5		62.0	60.0	

MP - Measuring point Mv - Median value * - Missed measurement

TABLE 2

Rise of Temperature above 55°C

	Baden-Baden	Bad Kreuznach
Edafil I	3rd day	4th day
Edafil II	3rd day	4th day
Proteg Oleo I	5th day	3rd day
Proteg Oleo II	3rd day	4th day
Zusätze-Frankfurt I	2nd day	4th day
Zusätze-Frankfurt II	2nd day	3rd day
Control I	3rd day	3rd day
Control II	2nd day	2nd day

Table three lists the processes according to the magnitude of their ammonia values.

TABLE 3

Experimental Variation in Ammonia Content in Decreasing Order of Magnitude

1st Turning		2nd Turning	
Baden-Baden	Bad Kreuznach	Baden-Baden	Bad Kreuznach
Control	Proteg Oleo	Control	Edafil
Edafil	Zusätze-Frankfurt	Zusätze-Frankfurt	Zusätze-Frankfurt
Proteg Oleo	Edafil	Proteg Oleo	Control
Zusätze-Frankfurt	Control	Edafil	Proteg Oleo
3rd Turning		**Pile Dismantling**	
Zusätze-Frankfurt	Edafil	Zusätze-Frankfurt	Control
Proteg Oleo	Control	Proteg Oleo	Zusätze-Frankfurt
Control	Zusätze-Frankfurt	Control	Edafil
Edafil	Proteg Oleo	Edafil	Proteg Oleo

TABLE 4

Speed of Temperature Rise

(measured in °C on the 7th day)

	Bad Kreuznach		Heidelberg	
	Single value	Median	Single value	Median
Multibacto I	66	67.5	63	63.5
Multibacto II	69		64	
B.D.-Starter I	68	68.0	62	62.5
B.D.-Starter II	68		63	
Control I	65	67.5	58	62.0
Control II	70		66	

Only one measuring point per pile.

TABLE 5

Rise of Temperature Above 55°C

	Bad Kreuznach	Heidelberg
Multibacto I	2nd day	6th day
Multibacto II	2nd day	4th day
B.D.-Starter I	2nd day	4th day
B.D.-Starter II	2nd day	4th day
Control I	3rd day	4th day
Control II	2nd day	3rd day

The results of the many experiments did not show any significant effect with the stimulating agents or inoculating agents that were used, with the exception that a trail experiment in 1959 in Heidelberg seemed to indicate a certain effect in piles treated with Edafil. An explanation of this conflicting data cannot be given at this time. It should be noted that the earlier results were based upon one trial whereas the later data were based on several repetitions.

The use of additives did not show any hygienic advantages. The destruction of pathogenic organisms occurred in equal time spans for treated and untreated piles. The increased costs and labor (of their use) would not be justified. This conclusion does not include the possible use of nutrients or additives in the composting of specialized commercial and industrial refuse that is low in microorganisms, or the inoculation of raw compost with finished compost as has been done successfully in several plants.

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6. Experiments on the Effect of Additives on Windrow Composting of Ground Household Refuse

by Dr. W. Obrist (Eidg. Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz, Zürich. Director: Prof.-Dr. O. Jaag).

The mixing-in of various additives of bacterial, enzymatic or chemical nature in refuse composting is recommended by firms that manufacture such products. In the composting of garden wastes, pH value is controlled by the addition of lime, and a more satisfactory C/N relationship is obtained by addition of nitrogen. The problems are very different with refuse. The pH value is generally only slightly acid, and rises above 7 after a short composting period. The C/N relationship is unfavorable, but in most modern plants is generally improved by the addition of digested sludge. In certain areas, winter refuse is especially poor in organic substance and also after composting, the refuse contains some non-decomposable materials (glass, ceramics, metals, rubber, plastics and salts).

Since the fastest and most intensive decomposition is desired, additives are sought to reduce the disadvantages of refuse composting and to render possible the most optimum decay process. In all previous investigations, bacterial substances and nutrients for microorganisms have been mainly checked. The addition of such inoculating material is considered valueless by Weststrate (1951), Golueke et al (1954), Gotaas (1956), and Straub (1961). This seems reasonable because raw refuse contains organism counts of several million per gram of wet weight and rapidly undergoes intensive decomposition. Some new data (Glathe and Atanasiu 1961), however, show that certain nutrients can cause intensification of decay and higher yields in plant experiments. It therefore appeared appropriate to conduct a few experiments on the influence of various additives, especially microorganisms and nutrients, on the decomposition of refuse. It was especially desired to determine which factors among the requirements for windrow composting can have a furthering influence upon decomposition.

Materials and Methods

The composting experiments were conducted, according to a method described by Keller (1962), in plastic bags of about 30 kg. capacity (raw refuse). The following mixtures were examined in a series of 4-6 mixtures with 2 samples of each:

Series A

	Refuse	Water	Additive
1		20 l.	(Control - no additive)
2	Each had 30 kg raw refuse from the refuse processing plant at Turgi, primarily bulky refuse and garden wastes, ground.	20 l.	150 g. Earp-Thomas bacterial, starter
3		20 l.	150 g. Earp-Thomas bacterial starter, autoclaved
4			20 l. sludge from activated sludge plant
5		20 l.	600 g. NH_4NO_3 (20% N) 600 g. $CaHPO_5$ 300 g. K_2SO_4
6		20 l.	900 g. Sugar

Series B

1		10 l.	(Control - no additive)
2	Each had 30 kg. raw refuse from the Küsnacht (Zurich) plant, residential refuse with much paper; ground, mixed and screened in an Egsetor.	10 l.	150 g. Earp-Thomas bacterial starter
3		15 l.	6 kg. shredded newspaper
4		10 l.	900 g. sugar
5			10 l. sludge from activated sludge plant
6		10 l.	1500 g. fertilizer N:P:K - 8:8:8

Series C

	Refuse	Water	Additive
1	Each had 30 kg. raw refuse from the Küsnacht (Zürich) plant, ground, enriched with sludge, mixed and screered in an Egsetor.	3 l.	(Control - no additive)
2		3 l.	Spore suspension of Thermomyces lanuginosus
3		3 l.	3 kg. refuse compost from hotter zone, mildewed
4		3 l.	15 g. fertilizer N:P:K = 8:8:8

Remarks about the individual additives:

Earp-Thomas bacterial starter: this is a bacterial mixture used by the refuse processing plant at Turgi (Baden-Brugg region) in a Multibacto digester in the same ratio (50 g. per 10 kg.). The carrier material for the bacteria is a peat soil mixed with mineral fertilizer and sugar.

Spore suspension: Thermomyces lanuginosus is the most widespread fungus in the thermophilic phase of refuse composting (v. Klopotek 1962). The spore suspension was made from a pure culture and was mixed with the refuse in water.

Refuse compost from the hotter zone: this is about one month old refuse compost from a windrow of the Küsnacht-Zürich plant. The material was obtained about 20 cm. below the pile surface, had a temperature of about 50°C, and was heavily mildewed.

All mixtures were made on the same day that the raw refuse was ground. Ten kg. amounts were mixed by hand with the additives and loaded into the plastic bags. The bags, which had air holes on all sides, were placed in Series A and B into an unheated hot house during summer; Series C was placed in a cellar held at a constant temperature of 21°C. Depending on the degree of decay and moisture content, the mixtures were mixed from time to time and moistened if necessary.

The following measurements were made:

1. In all series: temperature, moisture content.

2. In individual series: pH value, germ count, cellulase (enzyme) activity.

Germ count determination followed the Koch plate method with tryptose-glucose-beef extract agar (Difco). Measurement of cellulase activity was done by the viscosimetric method described by Schaefer (1957) and Hanstein (1960), with carboxymethyl-cellulose as substrate and compost extracts as measured by enzyme solution.

Results

Series A Temperature curves: see Figures 1 and 2.

Age, weeks	Moisture content, % of fresh weight Mixture No. 1	2	3	4	5	6
0	66	65	65	65	63	65
1	64	63	62	62	60	58
2	64	63	62	62	62	59
3	61	58	59	60	58	55
6	55	54	54	55	54	53

Series B Temperature curves: see Figures 3 and 4.

Age, Weeks	Mix.No.	Moisture content, % of fresh weight 1	2	3	4	5	6
0				All 50-55%			
1		39	43	52	39	40	41
2		41	45	50	40	39	38
3		38	41	44	37	34	32
4		35	41	44	34	33	32

Series C Temperature curves: see Figure 5.

Age, Weeks	Moisture content, % of fresh weight Mixture No. 1	2	3	4
0	51	51	54	51
1	46	44	50	44
2	45	44	48	43
3	43	43	45	41
4	47	44	44	46
5	47	42	45	41
7	47	46	49	48

Age, weeks	pH Values Mixture No. 1	2	3	4
0		All 5.8		
1	7.0	6.9	7.0	6.8
2	7.3	7.2	7.0	7.3
3	7.3	7.5	7.5	7.5
4	7.5	7.5	7.6	7.5
5	7.9	7.7	7.8	7.9
7	8.0	8.1	7.7	8.0

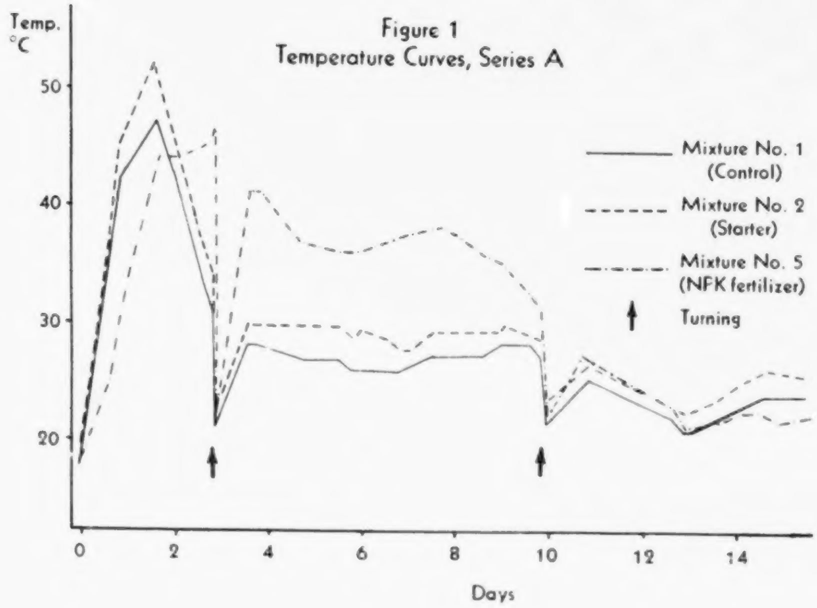


Figure 1
Temperature Curves, Series A

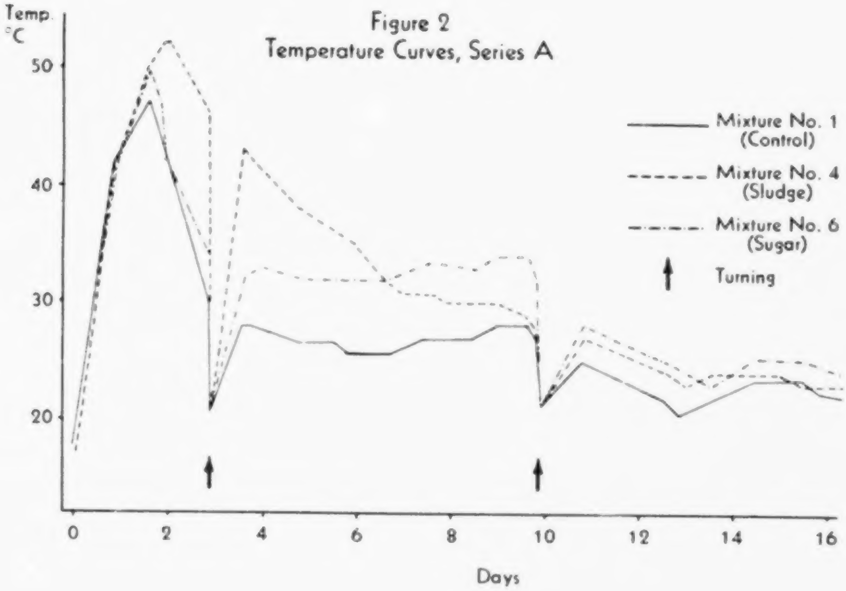


Figure 2
Temperature Curves, Series A

Figure 3
Temperature Curves, Series B

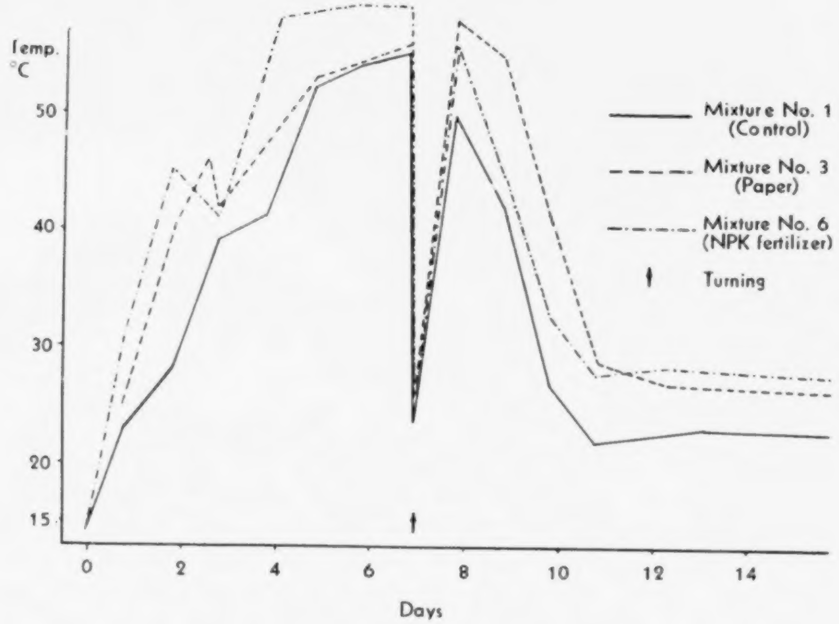


Figure 4
Temperature Curves, Series B

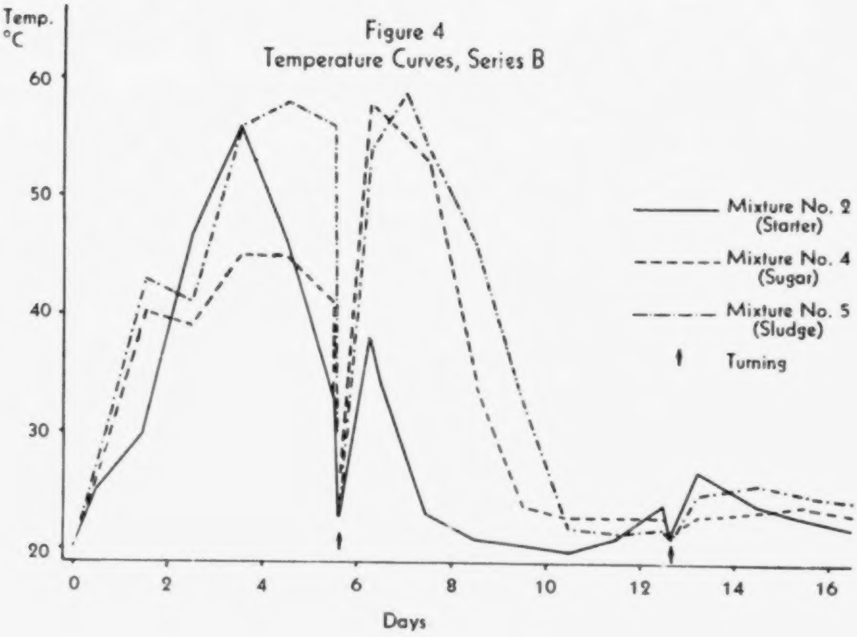


Figure 5
Temperature Curves, Series C

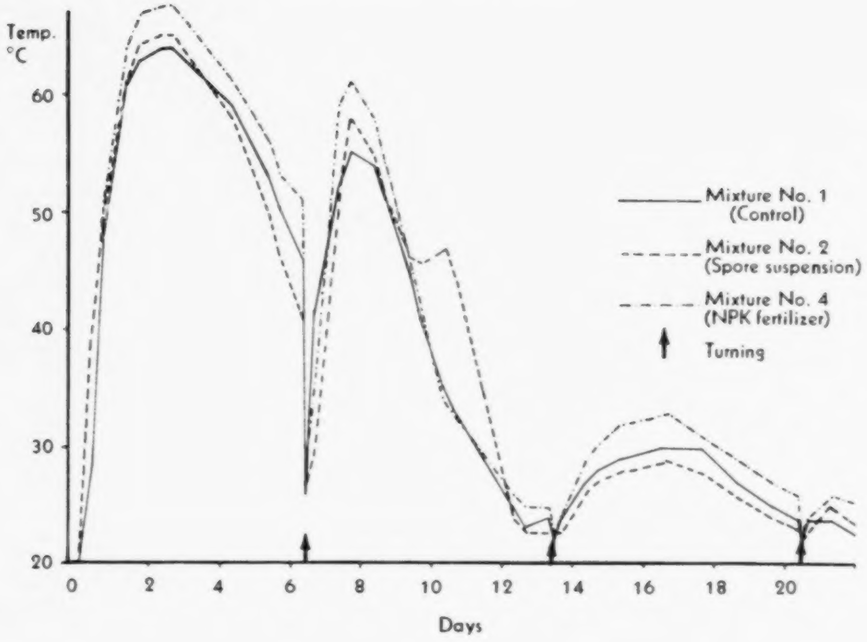
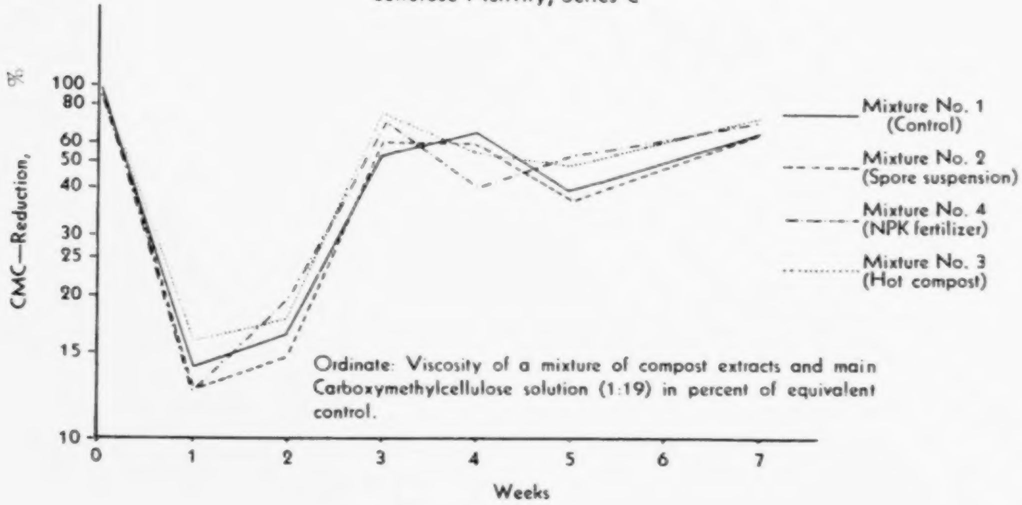


Figure 6
Cellulose Activity, Series C



Ordinate: Viscosity of a mixture of compost extracts and main Carboxymethylcellulose solution (1:19) in percent of equivalent control.

Germ Counts, Millions/g Fresh Material

Age Weeks	Mixture No.	1		2		3		4		5		6	
	Incubation Temperature	24°	54°	24°	54°	24°	54°	24°	54°	24°	54°	24°	54°
0		All 0.25 at 24° and 0.005 at 54°											
1		7	0.8	15	1	10	0.4	15	0.1	14	0.2	80	0.7
2		3	2	30	3	50	4	65	1.1	50	8	800	4
3		55	0.3	15	0.3	1000	0.5	100	20	750	20	250	1.3
4		90	0.2	450	2	4000	0.4	550	1.2	1300	0.6	2500	0.5
5		350	0.1	600	1	9000	0.2	1100	1.0	11000	1.5	6000	0.5
7		120	0.2	80	0.4	5000	0.3	6000	0.3	8000	1	1200	0.6

Discussion of Results:

Results of our experiments permit comparisons only within the series since the starting products, especially the refuse, can exhibit very different compositions. This is also the reason why it is practically impossible to obtain good statistical results. The experiments can, however, give indications as to the type and magnitude of those requirements which are of importance for decomposition. Consideration of individual results follow:

1. Microorganism additives (inoculating materials). Such additives of bacterial, fungal or mixed type show only a minor influence on temperature curves while germ counts are slightly increased. The cellulase activity shows greater differences from which conclusions cannot be drawn because of the lack of comparison possibilities.

2. Organic nutrients (stimulating agents). The materials tested - sugar, cellulose and sludge - can stimulate decomposition slightly. The start of aid depends on the speed of decomposition, but the effect is depleted faster with an increased speed.

3. Inorganic nutrients. The addition of N-P-K fertilizer to ground household refuse acted, even in relatively low concentrations, as an enduring positive influence on the measured decay characteristics. The temperature increased slower initially but remained longer at higher values. The germ counts and cellulase activity were increased and visible mildewing was more intensive.

Conclusions

The addition of microorganisms in windrow composting of residential refuse, with its relatively long decomposition time, is practically useless. Organic and, particularly, inorganic nutrients further decomposition in a refuse of one-sided composition. It is therefore concluded that the nutrient content of refuse is not always optimum for desirable microbiological fermentation.

Further experiments are desired, preferably with standardized refuse, to determine which nutrients and concentrations are needed for optimal microbiological reduction of the refuse.

It was shown that the addition of the tested stimulating agents and inoculation material is useless, or at least uneconomical, for practical refuse composting. This is different when plants with digesters are used in which the fastest possible composting is wanted. In this case an addition of nutrients could be of importance, but there are insufficient data available about this.

We thank Miss F. Deubelbeiss for her valuable assistance in the experiments.

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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NO. 20

MAY 1964

Ferguson, Brooks & Kelly, translators
John S. Wiley, editor

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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)
Information Bulletin No. 20

1. Requirements of Veterinary Hygiene in the Removal of Urban Refuse*

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Reprinted with permission from the Zentralblatt für Veterinärmedizin, Series B, Vol. 10, No. 3 (1963), Publisher: Paul Parey, Berlin and Hamburg.

All refuse, coming from residences, stores, commercial and industrial plants, is designated as urban refuse. It can be in a solid or liquid state. Domestic refuse, street sweepings, refuse from open-air and indoor markets, slaughterhouse and stockyard refuse, industrial and trade refuse, including fly-ash, are classed as solid refuse materials. Domestic and industrial sewage, sewage and sludge from individual toilets and septic tanks are considered liquid wastes. When urban refuse is mentioned in the following, it is to be considered domestic refuse and sewage sludge.

The amount of urban refuse varies widely. One may expect 180-220 kg/cap/yr of domestic refuse. In the Federal Republic of Germany this amounts to 12 million cubic meters per year for which an area of 2500 hectares are needed for dumping (Straub 1960). The sewage sludge consists of mineralized and organic filth materials which have been separated from the sewage in treatment plants. Human feces amount to an average of 480 kg/cap/yr. Industrial wastes are expressed in "population equivalents" for comparison with municipal sewage. For example, the sewage of a tanning factory processing one ton of hides amounts to a population equivalent of 1,000 to 4,000. Therefore, a tannery processing a ton of hides daily loads a treatment plant or river as much as 1,000 to 4,000 urban population. In the German Republic over one million tons of sludge yearly are collected which at this time can only be disposed of by dumping (Straub 1960).

The disposal of this urban refuse was previously mainly by dumping. The refuse was dumped in piles around the outskirts of cities, likewise the sewage sludge. Only recently were energetic measures started for the protection of watersheds, rivers, and air by adoption of new laws. These laws almost totally prohibit the dumping of urban refuse. The lawmakers want to prevent the dumping in new areas, after exhaustion of the present dumps, which could be harmful to the groundwater. It is possible through leaching of the dumps that disease organisms and chemicals enter the groundwater and cause contamination and hardness. Runoff from dumps could also further increase the load on the biological self-purification powers of the water-course, already in heavy demand. Similar problems occur in the dumping of sewage sludge. Local authorities, under pressure by these new laws, are forced to look around for other methods of refuse disposal.

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*Report of the 5th Congress of DVG, October 6-7, 1962, Bad Nauheim

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Essentially, there are two methods of refuse disposal and these are incineration and composting.

Incinerators are still so expensive that only a few large cities have decided to use them. The organic ingredients of refuse are mineralized in such plants. This process is often designated as hygienically unobjectionable. From the hygienic standpoint of epidemics this might be true. One often forgets, however, that unwanted minerals are leached into the ground from mineralized incinerator residues and thereby again form a danger to the health of humans and animals. The smoke and ash of incinerators are hygienically objectionable, as far as they are not held back.

It appears that financial reasons bar the use of incinerators by smaller and middle-sized cities. Such communities will turn increasingly to the composting of their refuse. This method of refuse disposal offers financial advantages, is attainable without a large capital and permits, under certain conditions, the processing of all of the sewage sludge (Straub 1951).

Numerous experiments have proven that refuse as well as sewage sludge can contain pathogens which endanger the health of man and animals. The compost produced by the composting process is used in nurseries, in public parks, in agriculture and in forestry. As soon as the compost is used in agriculture, there exists in it a potential epidemic danger which can only be considered as eliminated upon proof that in the course of an appropriate composting process, all pathogenic organisms have been destroyed. The same reasoning applies to the use of composts in public parks and in forestry. Dogs, cats, and birds come in contact with the compost in parks, and in forestry this also applies to the wildlife, which is just as epidemic-endangered as house animals.

In the opinion of a few experts, domestic refuse does not pose special health hazards for man. For animals which are fed with it, this is not true. One refers to the cases of trichinosis in the U. S. A. which occurred after feeding of hogs with garbage. Differentiation should be made between direct infection of swine through kitchen wastes and indirect infection of the animals through the eating of mice and rats which live on the garbage dumps. In the U. S. A., 77 percent of the mice and rats in garbage dumps were infected with trichina (Knorr 1957). In this connection, one remembers the outbreaks of swine plague and Newcastle disease which occurred in Germany after the feeding of pigs and chickens with kitchen wastes from the armed forces. In room sweepings with stove residue, typhoid and paratyphoid bacteria survived 115 to 136 days and anthrax bacillus over 80 days (Hilgermann 1908). These results were later checked and extended in that flies take up typhoid bacteria from infected kitchen wastes and spread it with their legs and feces (Kister 1928). To these are added numerous other disease germs which can enter refuse through old bandages, pus and sputum. In this connection special attention should be focused on the fact that the sputum of tuberculous people can be present in the refuse.

A much greater danger to man and animal is presented by sewage sludge. Sewage sludge can contain particularly large numbers of pathogens which enter the sludge from sewage during the sedimentation process. Disregarding pathogens communicable from man to animal, there are some specific animal disease organisms present in sewage. The sources of contamination of sewage with these organisms, other than human excrement, are principally the stockyards and related plants such as butcher shops, locker plants and sausage factories; the fish industry; rendering plants; cat-gut plants; dairies; and cheese plants (Strauch 1954). From representative examinations, Schaal (1958, 1959, 1960, a, b), also Wagemann and Schaal (1959, 1960), found that slaughterhouses and stockyards are the primary sources for the contamination of sewage with animal disease organisms. The following animal disease bacteria have so far been found in sewage: paratyphoid, tubercle bacillus, erysipelas, brucella, anthrax, tularemia and leptospira. Of the viral animal pathogens, the organisms of hoof and mouth disease and of swine plague have been found in sewage. Besides these, the organisms of the following viral diseases have been found occasionally in sewage: "Borna'sche" disease, chicken paralysis, swine paralysis, distemper, rinderpest, fowl pest, infectious anemia of horses, rabies, poliomyelitis, epidemic hepatitis, trachoma, swimming pool conjunctivitis (Strauch 1962).

All these pathogens settle in the sludge during sewage treatment. In most German sewage treatment plants the fresh sludge is decomposed in digesters and it loses two-thirds to three-fourths of its volume in the process. An alkaline fermentation occurs in a well-designed digester (Imhoff 1960). As a result carbon dioxide, nitrogen and, particularly, methane are given off. The pH-value remains over 7.0 at all times. This process is odorless. The action of alkaline fermentation is extraordinarily strong. In an active digester the sludge is almost completely decomposed in two weeks if sufficiently warm (55°C), so that its original organic ingredients are practically unrecognizable. Mesophilic decomposition is primarily used in Germany at an optimum temperature of 28°C. It is questionable if all disease germs are destroyed in this process. There are numerous investigations of this. A few authors (Popp, Bahr and Goernandt 1955) claim to have found organisms of the salmonella group just as prevalent in digested sludge as in the sewage itself. They therefore emphasize that sewage sludge be treated the same as sewage itself when viewed from the disease standpoint in the case of agricultural use. Tubercle bacillus have been found in dried sewage sludge after two years (Mueller 1959). One can say in summary that alkaline sludge decomposition is not able to free the sludge from all pathogens and that one must therefore always consider their presence in all sludge from mesophilic digestion plants.

As unsatisfactory compost from urban refuse presents a disease hazard to animals for agricultural use, it was necessary to determine if it is possible to destroy all pathogens through composting so that the compost can be designated as hygienically unobjectionable.

We therefore conducted experiments at various compost plants. We made a standard refuse which was placed in a porous perlon bag. This bag was then infected with a known number of animal pathogens and then placed in compost piles. At various time intervals the bag was removed and examined by various bacteriological procedures in the laboratory for the presence of the injected disease germs. The following pathogens were used: 1. Bacillus anthracis, 2. Salmonella enteriditis, 3. Erysipelothrix rhusiopathiae, 4. psittacosis virus. All these germs can occur in refuse or sewage sludge.

In numerous experiments the following results were obtained: With appropriate composting of unground refuse with sewage sludge, of ground refuse without sludge, and of refuse with sludge from the Dano biostabilizer, it was possible to destroy Salmonella enteriditis, Erysipelothrix rhusiopathiae and the psittacosis virus in the usual composting time. It was also possible to destroy Bacillus anthracis if the material had a moisture content of 40-60 percent and the composting continued at least 3 weeks at a temperature above 55° C. In order that the anthrax spores can germinate, the temperature increase in the composting should be regulated so that the zone of higher temperature (over 55° C) is not reached before a lapse of 3 days. So that all parts of the compost windrow come into direct contact with the influence of the decomposition process and the higher temperatures, it is necessary that the windrow be turned at least once after 3 to 4 weeks. So-called cold composting should be rejected on hygienic grounds because anthrax bacillus were still virulent after 251 days under these conditions. It was further determined that, during the course of composting, materials appear which hinder bacterial growth. Such inhibitory substances seem to play an important role in the decontamination of the compost besides temperature. Our experiments also showed that it is not possible to draw conclusions on other processes by the effect on pathogen destruction of one composting process. Each process should be separately examined before it can be regarded as hygienically unobjectionable.

The following can therefore be concluded: Composting will be increasingly used in the future for processing urban refuse. Such refuse contains germs pathogenic to man and animals which are not destroyed through physical treatment. When compost from such infectious materials is used in agriculture and forestry, there exists a danger of infection for agricultural workers and wildlife. Our own experiments showed that it is possible to decontaminate urban refuse by composting through adherence to certain requirements so that such compost may be used without danger in agriculture and forestry. With the increasing use of such products from urban refuse in agriculture, it is justifiable and necessary for veterinary authorities to examine the compost plants whenever disease outbreaks of such type are suspected. It would also be advisable for the authorities to make the licensing of composting plants dependent on an examination of the composting operation by a veterinary hygienist, since only such an examination can determine the hygienic safety of a compost. It is further suggested that suitable guidelines be established for the hygienic examination of composts by coordination of public health and veterinary authorities.

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2. An Investigation on the Significance of Plant Size for Refuse Disposal by Incineration or Composting in Rural Areas

by Dipl. Ing. K. Wuhrmann, EAWAG, Zürich.

The safe disposal of residential and industrial refuse is not only an urgent health problem but also an economic problem. Formerly it sufficed if one simply hauled these materials out of seeing distance and also, if possible, out of smelling distance. The rest was left to nature.

As population density increased, the results of water and air contamination became more and more apparent. It became impossible to avoid the construction of disposal plants, particularly incinerators or compost plants.

Even small communities and less densely populated areas can no longer avoid the safe disposal of their refuse, which fact places urgent and difficult problems before them. The fact, known from industry, that plant size plays a very important role in specific operating costs is especially apparent in refuse disposal plants in which only low value products are treated. Even the per capita investment for the plant itself, whether for composting or incineration, increases as the community size decreases.

Plant construction costs for a city of 100,000 inhabitants is approximately twice as high per capita as it is for a large metropolis. The same applies to annual operating costs. If the plant is built on a still smaller scale, then today's requirements for a complete, totally satisfactory plant, drive the costs to the limit that can be borne. There is an unavoidable demand for centralization and joint construction; that is, the joining of individual communities in a region.

It is evident that the refuse destined for regional disposal plants must be transported greater distances, not only in comparision with imperfect disposal methods practiced till now, but also in comparison with plants constructed for large cities or densely populated areas. In fact, until just recently, there has been a tendency to choose unreasonably low figures for the calculation of operating expenses of refuse treatment plants which has given rise to a false idea of the existing connection between transporting and operating costs -- a connection very important for regional planning. Optimum use of operating funds can occur only if the various cost components are known on the basis of effective value based on practical experience. Projected operating costs often prove to be very illusory in this new area of science.

Computation of operating costs show that only refuse plants of equal size can be compared. The following classification is made:

Type 1: Simple plants. Process only residential refuse and part of the bulky wastes and industrial refuse. Remaining materials must still be dumped.

Type 2: Standard plants. Process residential refuse, bulky wastes and industrial refuse except sewage sludge, oil wastes, carcasses and neutralization sludge. Operates more on an assembly-line basis.

Type 3: Complete plants for all wastes except inert material such as building rubble, etc.

In rural areas, only Types 1 and 2 are required as yet.

Determination of annual costs can be approximately determined on the basis of completed project comparisons which are shown in the following tables:

Composting Plants				
Yearly capacity (total use)	6,000 T/yr. Type 1	6,000 T/yr. Type 2	18,000 T/yr. Type 1	18,000 T/yr. Type 2
Digester	1	1	1	1
Glass removal unit	1	1	1	1
Bulky waste grinder	--	1	--	--
Plate bin	1	2	--	--
Grab crane and bin	--	--	1	1
Incinerator	--	1	1	1
Shovel loader	1	1	1	1
Cost in Million Francs				
Machinery	0.8	1.2	2.1	2.8
Building	0.4	0.5	0.7	0.9
Foundation	0.1	0.1	0.3	0.3
Project and misc.	0.1	0.2	0.4	0.6
Total to 1965	1.4	2.0	3.5	4.6
Incinerators				
Furnace	1	2	1	2
Smoke cleaner	1	1	1	2
Bin plant	1	1	1	1
Bulky waste grinder	--	1	--	1

	Cost in Million Francs			
Machinery	1.2	1.6	2.0	2.8
Building	0.3	0.5	0.6	0.7
Foundation	0.1	0.1	0.3	0.3
Project and misc.	0.2	0.2	0.3	0.4
Total to 1965	1.8	2.4	3.2	4.2

This gives the following installation and operation conditions for refuse as delivered:

		6,000 T/yr		18,000 T/yr	
		Type 1	Type 2	Type 1	Type 2
Hourly output, tons/hour:	Composting	4	4	10	10
	Incineration*	2	3	4	8
Yearly Operation, hours:	Composting	1500	1500	1800	1800
	Incineration	3000	2000	4500	2250
Number of shifts **	Composting	1-1/2	1-1/2	1-1/2	1-1/2
	Incineration	2	1-1/2	3	1-1/2
Personnel:	Composting	4	5	6	6
	Incineration	6	6	9	7

* The low hourly capacity for incineration is allowable as there is no after-treatment necessary for the materials.

** For composting: yearly operation hours + 100% for round trip; divided by 2300 hours.

For incineration: yearly operation hours + 30% for round trip, divided by 2300 hours.

On this basis it is possible to make an approximate calculation of operating costs if the following values are taken into account:

Power Use: Composting; Type 1 30 Kw-hr/T; Type 2 40 Kw-hr/T

Incineration; Types 1 and 2 40 Kw-hr/T

Water Use: Incineration 3 m^3/T

Maintenance and repairs: 3% p.a. of the mechanical part of the plant for composting and 2% for incineration plus 1% p.a. of the building costs.

The capital service is uniformly assumed at 9% p.a. for the machinery and 7.3% p.a. for the buildings, corresponding to 15- to 20-year amortization.

Yearly costs for different plants:

		6,000 T/yr		18,000 T/yr	
		Type 1	Type 2	Type 1	Type 2
Composting:					
Personnel, in 1000 Francs/yr		60	75	90	90
Electricity, at 7 Rappen*/Kw-hr		13	17	39	51
Water		--	--	--	--
Heat and diesel oil, at 20 Rp/kg		4	4	12	12
Maintenance and repairs:	Machinery	24	36	63	84
	Buildings	4	5	7	9
Processing costs		105	137	211	246
Capital amortization:	Machinery	72	108	189	252
	Buildings	36	44	73	88
Total in 1000 Francs/yr		213	289	473	586
in Francs/T		35	48	27	33
Incineration:					
Personnel		90	90	135	105
Electricity, at 7 Rappen/Kw-hr		17	17	51	51
Water, at 20 Rp/m^3		4	4	11	11
Heating oil, at 12 Rp/kg		5	5	15	15
Maintenance and repairs:	Machinery	24	32	40	56
	Buildings	3	5	6	7
Processing Costs		143	153	258	245
Capital amortization:	Machinery	108	144	180	252
	Buildings	29	44	66	73
Total, in 1000 Francs/yr		280	344	504	570
in Francs/T		47	57	28	32

* Rappen = 1 Swiss centime (approximately 0.23¢)

In Diagram 1, the calculated yearly costs depending on the amount of refuse processed are shown in order of size. The inevitably higher costs of smaller plants is obvious. The larger the region, that is the more residents served by the same plant, the cheaper it is per capita. In the same diagram an approximate conversion is made between the quantity of refuse per year and the population based on a quota of 180 kg/cap/yr. A lower per capita amount has to be used for rural districts in Switzerland because the number of farm residents served by the refuse collection system is smaller than the whole population according to statistics. On the other hand, there are always industrial wastes, and possibly sludge, to be added which makes the relation between population and yearly quantity somewhat variable. For example, for 50,000 residents served, or 9000 T/yr, we must figure costs between about 32 and 48 Francs/T, depending on the kind of plant and amortization; where composting plants are on the lower, and incinerators on the higher, end of the costs.

Annual costs are made up on one side from the operating costs which are more or less similar for all plants, and on the other side from the capital costs which depend on planned future developments and reserve capacity.

There are also relationships between the population served and the hauling distance to the joint plant. Disregarding the special conditions in the case of large industrial plants with local heavy yields, the average population density is a measure for the calculation of the number of residents to the average hauling distance. Neither an ideal even distribution of the sources of refuse in the area served, nor an ideal use of the shortest hauling roads, can be expected.

In the following, an attempt is made to find the relationship between the population density, the regional area, and the average hauling distance; and to check the results of these stated values by means of a practical example. It is possible to improve the statistical knowledge in this field through additional examples.

The following assumptions and definitions are required:

1. Regional area = area of cultivable or usable ground.

2. Population density = number of residents per km^2 of the regional area.

3. Even distribution of residents in population units of not less than 25 km^2 area.

4. The same hauling conditions for all residents with respect to frequency, amount, loading and compression conditions of the collecting vehicles.

5. The geometrically shortest hauling distance to be enlarged by a constant factor based on the topographic conditions and the different sizes of population units.

6. The considerations are not valid in the case of high population density, such as large cities.

The considerations are based on the fact that only the hauling distance between the center of the district, which can be served by one hauling route, and the disposal plant, has to be figured. The average hauling distance of all routes is a factor for the over-all economy of the arrangement.

Each collection route serves a certain area the size of which is determined by the loading capacity of the refuse collection vehicles or the geographic circumstances. Assuming the already cited unit quantity of 180 kg/cap/yr or 0.5 kg/cap/day; and a loading capacity of 5 tons, including a sufficient reserve per truck; a service group of 3,000 residents per route, or the equivalent industrial values, results with twice weekly collections. The area served per collection route is therefore $F = \frac{3000}{q}$ km^2, when q is the average population per km^2. This results in the following values for the different types of settlements:

Urban	q = 3000 E/km^2	F = 1 km^2
Suburban	1000	3
Rural	100	30

(E = number of residents)

As the purpose of these considerations is to find a usable way for this project in non-urban areas with low population density, the unit F=25 km^2 was chosen; which, with a population density of 100 E/km^2, compares to a small town of 2,500 residents (E) and therewith about the size of an average collection area. Different population densities result in certain inconsistencies, which are part of the inherent uncertainties.

The average hauling distance is figured geometrically assuming square unit areas and the shortest distances between the center of each unit area and the center of the region. For simplicity, only regions with a squared number of unit areas are considered.

In Diagram 2, the value obtained for population densities of q = 100 and 200 E/km^2 are shown. As control points, the values I to IV are also shown, originating from a practical investigation in a district of the Thur valley. It was conducted from the smallest region I to the largest growing region toward the lower course of the Thur (River) disregarding the Canton boundries between St. Gallen and Thurgau.

Number of Units	Total Area km²	Avg. Haul Distance km	Corrected Haul Dist.	Residents at q = 100	Residents at q = 200
4	100	3.5	4.2	10,000	20,000
9	225	5.4	6.5	22,500	45,000
16	400	7.7	9.3	40,000	80,000
25	625	9.6	11.5	62,500	125,000
36	900	11.4	13.7	90,000	180,000
49	1,225	13.3	16.0	122,500	250,000

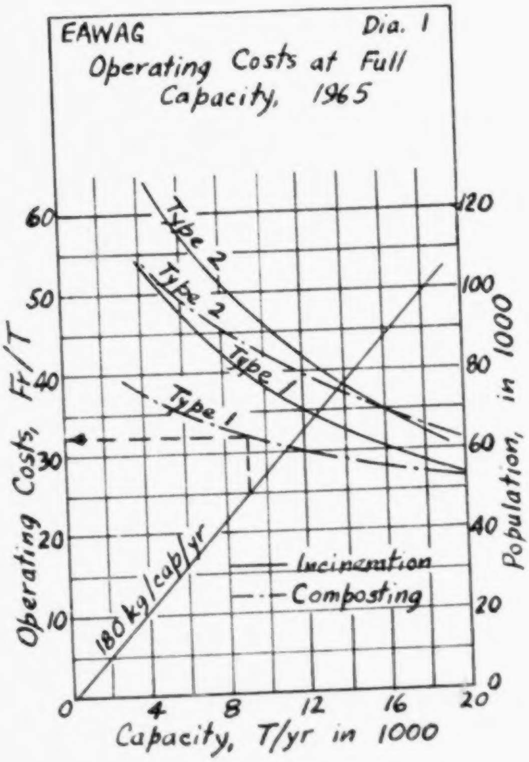
The correction of the hauling distance is 20 percent in this case.

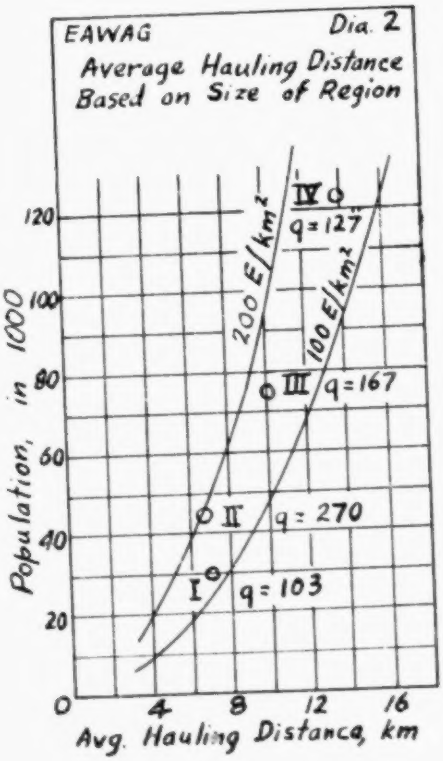
The hauling distances between the most advantageous site for the disposal plant and the center of town with at least 2,500 residents, or the population center of rural areas with about the same number of residents, were used.

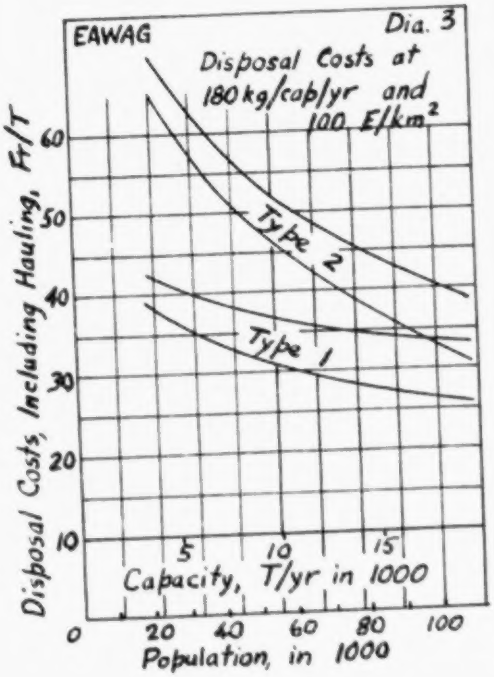
The type of disposal plant remained open so that the best location based only on transportation could be assumed. The regions are organized as follows:

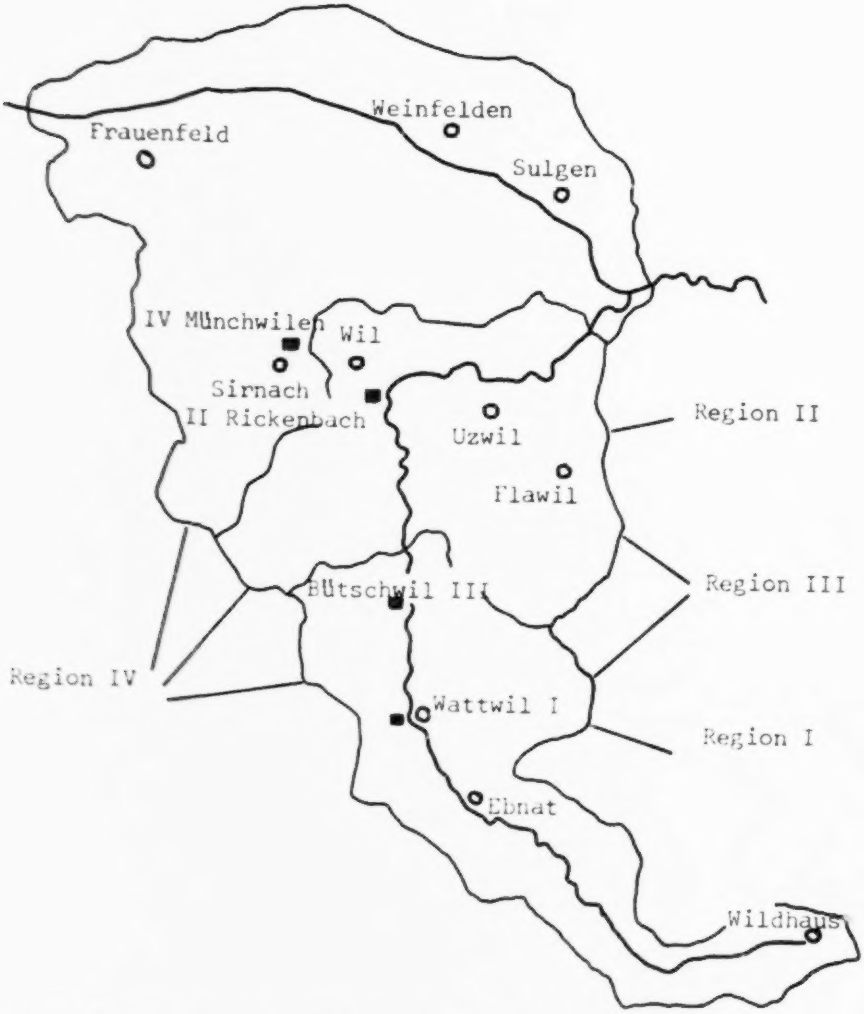
Region	Plant Location	Residents E	Area km²	Population Density E/km²	Average Hauling Dist. km
I	Wattwil	30,600	290	103	7
II	Rickenbach	44,600	160	270	6.6
III	Bütschwil	75,200	450	167	10
IV	Münchwilen	127,000	1,000	127	13.7

To be able to consider differing conditions as much as possible, the near-Alpine region I with only 103 E/km^2 and the densely settled area of region II centered at Wil with 270 E/km^2 were chosen. Region III is made up of regions I and II with a new selected location for the plant, while region IV includes the additional area of Frauenfeld and thus represents the Swiss midland. Even if one expects only partial agreement between theoretical and practical values, the results shown in Diagram 2 are still plausible.


EAWAG
Dia. 1
Operating Costs at Full Capacity, 1965
Operating Costs, Fr/T
Population, in 1000
Capacity, T/yr in 1000
Type 2
Type 2
Type 1
Type 1
180 kg/cap/yr
Incineration
Composting
0
10
20
30
40
50
60
0
20
40
60
80
100
120
0
4
8
12
16
20


EAWAG
Dia. 2
Average Hauling Distance Based on Size of Region
Population, in 1000
Avg. Hauling Distance, km
200 E/km²
100 E/km²
IV
q = 127
III
q = 167
II
q = 270
I
q = 103
0
20
40
60
80
100
120
4
8
12
16


EAWAG
Dia. 3
Disposal Costs at 180 kg/cap/yr and 100 E/km²
Disposal Costs, Including Hauling, Fr/T
Type 2
Type 1
Capacity, T/yr in 1000
5
10
15
Population, in 1000
0
20
40
60
80
100
10
20
30
40
50
60


Frauenfeld
Weinfelden
Sulgen
IV Münchwilen
Wil
Sirnach
II Rickenbach
Uzwil
Flawil
Region II
Region III
Bütschwil III
Region IV
Wattwil I
Region I
Ebnat
Wildhaus

The next step leads to comparison of costs based on the average hauling distance for the refuse from an assumed population quota and the practical hauling costs based on known costs per ton-kilometer. Based on the original assumption, we use 180 kg/cap/yr and a specific hauling cost of 0.5 Fr/T-km. This cost refers to a round-trip haul by a refuse truck with an average load of 5 tons. If smaller vehicles or vehicles with inadequate compaction are used, the rate will naturally be higher. Otherwise, for long hauling distances, the eventual possibility of transfer stations should be considered.

The following approximate values were thus obtained:

Refuse Quantity T/yr	Population	Avg. hauling dist.		Hauling costs	
		q=100 km	200 E/km^2 km	q=100 Fr/T	200 E/km^2 Fr/T
5,000	28,000	7.5	4.9	3.8	2.5
10,000	55,000	10.8	7.4	5.4	3.7
15,000	83,000	13.2	9.4	6.6	4.7

These hauling costs have to be superimposed on the yearly costs of the disposal plant as shown in Diagram 3. These costs refer only to disposal, including transportation, but do not include actual collection, which is independent of the size of plant selected.

It shows that, with only partial disposal of refuse in a Type 1 plant (all remaining materials must be dumped), acceptable economy could be attained at about 40 Fr/T for 50,000 residents, while with complete treatment in a Type 2 plant (only inert materials such as slag are dumped) savings seem very possible even with enlargement of the region to over 100,000 residents. With a greater density of population or higher per capita yield, the characteristics will change so that appropriate treatment costs must be added to the smaller hauling costs.

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3. Problems in Analysis of Refuse, Compost and Sewage Sludge*

by G. Rollé, EAWAG, Zürich.

1) Characteristics of the Material and Methods.

The first question in this connection is: Why and for what reason should refuse, compost and sewage sludge have to be characterized chemically and physically? If only household wastes were to be disposed of, the problem would be much simpler. Considered as material output, such refuse is somewhat different from area to area and city to city, but basically it is more or less uniform. This also applies to the compost produced.

As a simple orientation for a practitioner, it usually suffices to know the moisture content, the total and usable organic matter and perhaps the calorific value. These data are of interest in all disposal methods, whether dumping, composting or incineration.

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[*] Presentation at the working session of EAWAG, University of Giessen, April 1963, Giessen.

But additional problems come up if one works with industrial as well as domestic wastes. In this connection it could be very important to be able to examine the material produced. From the approximate composition of raw refuse, for example the C/N relationship, one can draw conclusions about the expected decomposition process. In spite of chemical analysis, practical composting tests on a small scale probably are unavoidable for some certain special conditions. Besides the practical importance of the research methods, the research studies are mostly responsible for analytical results. Thus, for example, determination of cellulose content is very interesting since the course of composting can be followed by this substance. The progressive decomposition of cellulose is a measure of the intensity of decomposition.

The examination of compost can have practical and scientific significance, as is also the case with the original material. Working rules and the extent of examination could be prepared accordingly.

In characterizing the compost as to its soil-improving action, the knowledge of its content of organic matter is very important. The moisture content should also be known. In many cases it is also desirable to know, besides the pH-value, the contents of nitrogen, phosphorus, potash, calcium and magnesium. The effort to determine these results should be in reasonable relation to the benefit.

The fact that refuse and compost are heterogeneous mixtures of many different substances and combinations, presents some difficult problems. Even before a sample for a particular analysis is available, different questions are raised. These come up in sampling, drying, grinding, and homogenizing. To get analytical results that are representative of the original material, the sample should be taken by sectioning as much as possible. This is an extremely critical undertaking. If, for example, the nature of the refuse in a region or city is to be determined, one should mix together the most homogeneous sample possible from deliveries from various communities or city districts because different trucks could contain very different refuse. If this problem arises in a plant with some grinding equipment, it is very easily solved. But very often the tests have to be made for the purpose of planning.

In this case it is very difficult to mix the sample at all. This leads to the conclusion that grinding and homogenizing should always be possible. For this reason the section on refuse research of EAWAG procured a portable hammer-mill.** This mill, mounted on a trailer of about 1-1/2 T weight, breaks up the refuse and homogenizes it on a second passage. This should make it possible to collect representative samples. The additional grinding to the fineness of flour is done in laboratory mills after drying.

** A report of the operation of this hammer-mill will follow at a later date.

A number of tests can be made on this dry, finely-ground refuse or compost. For certain tasks, especially of a biological nature, it would be of advantage to grind and mix the samples in a moist condition. To date, the tested devices have proved unsuitable. Additional tests on this are planned in the near future. This only indicates the problems of sample taking and preparation for further examinations.

The accuracy of the analysis plays an important role in the choice of methods. In principle, the highest possible accuracy should be attained when it is for scientific research. But in very many cases a relatively rough orientation about the interesting points will suffice; be it for routing control or for preliminary tests which should then serve as a base for additional work. Certain procedures should be inspected and controlled analytically in the composting plant. But personnel, place, and interest are necessary for this. It is clear that only methods and equipment which do not require very high demands on time and technical knowledge should be used. Reasonable automation and foolproofness should be required in such cases.

The question arises if it would not be advantageous to divide the new collection of methods in to two grades of difficulty; namely:

1. Scientific methods of the greatest possible accuracy which demand a high expenditure of time and apparatus.

2. Simplified methods, more economical considering time and equipment, but which permit sufficiently good results for control and orientation analyses.

The selection and adaptation of the methods offer great difficulties. Many instructions, which can usually be applied without difficulty, are unsuccessful for use with refuse and compost. In most other cases, tests are performed with pure substances, definite combinations or mixtures. Our raw material, however, is extremely irregular and heterogeneous. Any sample mixture can contain almost every type of substance. Depending on what occurs in the refuse more or less by chance, one has quite often to deal with completely different proportions from sample to sample. Thus, many uncontrollable troublesome factors occur in the material being tested. This influences many proven analytical methods so that they are completely unsuitable or can only be used after many tests and modifications. A method has to be proven satisfactory on artificial test mixtures and on refuse samples with troublesome substances in a large proportion of trials. As an added control, known samples with greatly varying amounts of interesting and troublesome substances should be tested. Only then can one be relatively protected against unpleasant surprises.

The output of time for such work is naturally very great, but the introduction of new methods is an important challenge.

2) Efforts at Standardization of Methods of Analysis.

The goal of these efforts is to obtain really comparable results from all participating laboratories through unified and standardized methods of analysis. Only then can international cooperation be intensified and completed. The beginning has already been made with the existing "Methods for the Examination of Refuse and Refuse-Sludge Composts" issued by IRGRD. We are quite sure that some of the methods described there are in need of renovation. It stands to reason that one should proceed in two directions: the first a collection of methods for scientific purposes, and the other for rapid and routine control. As cost of equipment for such accurate analysis with new procedures is rather high, a separation seems necessary if only for this reason. This applies especially to colorimetric and flame spectrophotometric methods which are very successful and which should by all means be used.

Within the framework of IRGRD, a form of cooperation should be found to develop this collection of methods. We think of this cooperation in the following way: All different methods from the various interested laboratories, institutes, and research centers should be collected. This compilation, supplied with experienced commentary, would provide a good summary. Also the literature, especially in the field of soil chemistry, should be thoroughly examined for new works. Thereafter the most promising methods should be tested and modified if needed.

When a method has proven itself with test mixtures and known samples, it should be tested in all participating laboratories. It would not be surprising if the directions would not always give good reproducible results. As a result of these extended tests, additional revision should be made. Only then can it be expected that comparable results will be attained. This goal should be attempted as only then is standardization of our methods acceptable. The second collection of control methods should also be worked out in the same way. Here trials should be made in plants interested in such test instructions.

One can clearly see that such an extensive standard is only possible if the laboratory equipment is also very similar. For this reason it is planned to make up a list of applicable equipment, especially for various types of measuring instruments.

It is a very large problem for the solution of which everyone must by all means work together. Only with an intensive exchange of thoughts, ideas, and literature within IRGRD and other interested groups can a standardization of methods of analyses be reached in a reasonable time. We are sure that such standards would also act very positively on other works. Through the initial or intensive cooperation on an international basis, contacts would be made and expanded which would lead to discussions finally among laboratory interests, particularly of a technical nature.

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4. Abstracts
   From "Mededelingenblad van de N.V. Vuilafvoer Maatschappij 'V.A.M.'," No. 4, 1963 concerning the market for compost in the Netherlands:

In the Dutch compost plants, which have transferred the sale of compost to V.A.M., the following situation existed at the end of 1963:

1) "Landbauqualität" (farm quality) was in greater demand in Wijster than in previous years.

2) The demand for "Gartenbauqualität" (garden quality) was again increased. This is due to increased use in flower bulb cultivation.

3) "Extra feine Qualität," so-called "Edelkompost" (extra fine quality), was also in great demand, resulting in increased production.

4) The newest V.A.M. product, "Müll-Torf-Kompost" (refuse-peat-compost), production of which only started a few years ago, also showed a very large increase in demand.

5) The pre-sale of "Mülltreibmist" (refuse heating manure) is (December 1963) in full swing. Apparently the demand will be higher than ever before.

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Since 1959 the following changes are apparent in the compost market in the Netherlands:

1) The use of compost in gardening increased to about 70 percent. This stems from greater use in flower bulb cultivation, fruit- and vegetable-growing under glass. In the latter case Treibmist (heating manure) is largely used.

2) The use of compost in playgrounds, parks, sports fields, roadside and private gardens increased by 35 percent.

3) In agriculture the use of compost declined. This was due partly to bad results on the farms and partly to greater use of stable manure because of larger cattle herds.

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Compost has been used with evidently good results as a covering of rose beds by some garden departments.

A. v. Hirschheydt

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Information from Industry

5. A New Machine for Grinding Bulky Refuse by Dipl. Ing. F. Kummer, Zürich.

The Firma von Roll AG, Zürich, which has built, or has under construction, in the last 10 years, refuse incinerators in 13 medium and large cities; has been asked frequently by its customers to include a machine for grinding the ever-increasing amounts of bulky refuse in their plants. Certain wastes, because of their shape or volume can not pass the furnace openings (cabinets, tables, boxes, mattresses, building wood, tree trunks and poles, tree trimmings, larger cardboard boxes); other wastes, because of their consistence, could interfere with normal incineration (large tires, filled metal drums, etc.). It is important to grind these wastes with a minimum of energy and personnel expenditures so as to enable complete combustion with the rest of the urban refuse. The grinder must also be able to cope with metalic wastes which are or could be contained in bulky wastes (iron bars, tracks and ornaments, bed springs, bicycle frames, etc.). The machine must therefore meet the following principal requirements:

1) Ease of charging, even very bulky goods such as cabinets, long building lumber and tree trunks, etc.

2) Grinding of the most varied materials, especially very tough or elastic pieces of refuse (tires, bed springs).

3) Minimum power requirement with an operating method which prevents too extensive grinding and produces a constant size of pieces suitable for incineration.

4) Minimum labor requirement by means of an automatic grinding process: charging controlled by a refuse crane operator or by another worker depending on the local situation.

5) Lowest manufacturing cost through the use of the building block system for various sizes.

There was no machine on the market made principally for shredding bulk refuse and therefore none satisfied the various requirements. Available machines would have to be modified, without a guarantee of a satisfactory end product. Therefore Von Roll decided several years ago to develop an entirely new machine. This special product has now reached the mass production stage.

The machine is capable of automatically grinding all of the mentioned materials, singly or mixed. Capacity depends largely on the volume of the individual wastes and with large goods (cabinets, beds) it reaches a maximum capacity of 200 m^3/hr of bulky refuse. With medium-sized pieces, the capacity is around 100 m^3/hr.

The requirement of ease of charging was solved by a large horizontal opening of 3.4 x 3.7 m which requires no special feeding arrangement (such as a vibrating trough, etc.). Very bulky goods will bridge over the charging opening. With proper installation this machine can be fed by means of a claw crane which is usually available at a refuse bunker.

By use of a cutting process it is possible to shred practically all bulky materials, such as wood, cardboard, mixed and ferrous metals (iron profile up to a size of NP-20), mattress filling material, and especially tires, which are always present in large quantities at an incinerator. The cutting is done by durable and exchangeable knives which each have four cutting edges. Only one cutting edge is used at a time so that the knives can be turned three times before they have to be sharpened or replaced. The renewal rate of the knives is negligible.

The third requirement of minimum power use was taken care of by the following construction details of the machine: The machine basically consists of one movable and one fixed rake assembly of steel. Each part is enclosed in a steel frame. The swing motion of the movable rake occurs around a rotor which joins the fixed and movable rakes with one another. The structural steel parts of both rakes are 30 cm wide. The knives are fastened to their edges. During operation the rakes interact so that pieces of a constant 30 cm size are cut off. Too extensive grinding is avoided and production requirements are met. This process also permits minimization of mass energy and of idling power so that only 37 kw installed motor power is used, that is a power intake of 30 kw.

Another reason for the low power demand is the very practical hydraulic drive and its regulation. A hydraulic pump transfers the electric motor power by means of oil pressure to two hydraulic pistons which convert the energy into mechanical movement of the knife-equipped rakes. As the relatively slow movement of the pistons has to be done with relatively great strength, a hydrostatic drive was chosen; that is, a drive which allows a lower speed of the working medium (oil pressure) with a high working pressure. The hydraulic pump is equipped with a power regulator. This regulates the pump automatically and continuously, depending on the rake resistance, so that the speed of the rake and the product of oil movement (and thereby the rake speed) and oil pressure remains constant. As this product is identical with the maximum power intake of the motor (30 kw), the purpose of the regulator is therefore to use the motor constantly at full capacity or at maximum efficiency.

Technical Data:

Width 4 m

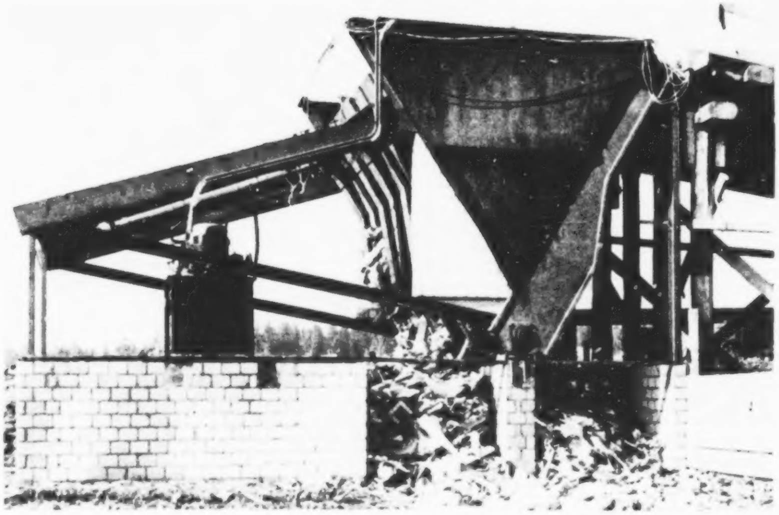
Length 8 m

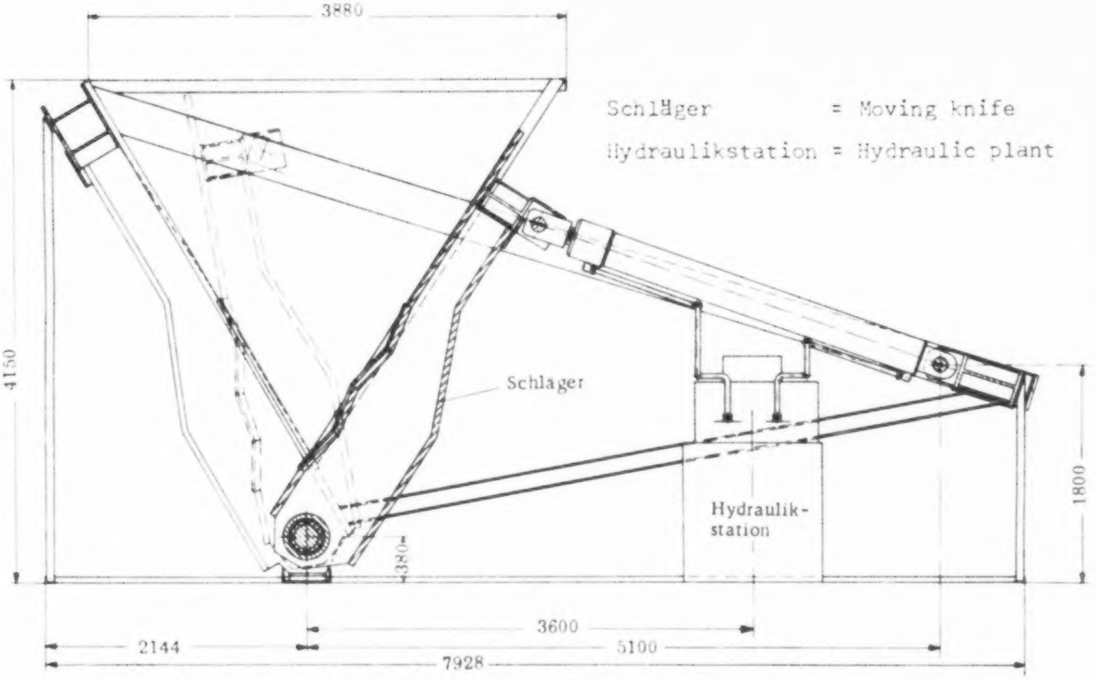
Height 4 m

Total weight 33 T

Throat 3.7 x 3.4 m

Motor capacity,
installed 37KW





Schläger = Moving knife
Hydraulikstation = Hydraulic plant

3880
4150
Schlager
Hydraulik-
station
1800
380
3600
2144
5100
7928

Finally, the machine is equipped with automatic controls which permit the unattended shredding of bulky wastes thus eliminating labor with the exception of the crane operator for charging the machine. If the maximum oil pressure is surpassed during the shredding operation (this seldom occurs), then the reverse movement is automatically initiated. This permits the bulky goods to slide farther into the machine so that the increased lever arm and thus the increased pressure on the material permits it to be cut in the next working movement. As a result, even during movements of extreme power requirement, no standstill occurs and constant charging is possible.

The machine was installed on a building-block foundation in order to lower costs and to satisfy the widest range of customers; the number of knives can be decreased or increased within certain limits so that the width of the present machine (4m) can be reduced by half (about 2m) or increased 50 percent (about 6m). At a width of about 2m, the throat of 1.5 x 3.7m is still large enough to cope with almost any material without the need for sorting. However, the capacity of the machine is halved. The normal model of 4m width should be used in most cases as it is optimum for the commonly occurring bulky materials.

In closing, it should be mentioned that the shreeding machine for bulky wastes is very suitable for communities which still dump their refuse. If the bulky goods, including bulky iron objects such as bicycles, auto bodies, barrels, refrigerators, washing machines, etc., are shredded, it not only reduces the dump volume considerably but also leads to a greater and faster compaction of the refuse layer, thus reducing the fire hazard because of reduced air passages.

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6. Book Reviews

Müll-und Abfallbeseitigung (Refuse and Waste Removal). Handbook on the collection, removal and utilization of refuse from households, communities and industries. Published on the recommendation of the Federal (German) Ministry of Health by Prof. Dr. -Ing. E.h.W. Kumpf, Lt. R. Dir. K. Maas, Oberbaurat Dr. -Ing. H. Straub. Publisher: Erich Schmidt, Berlin-Bielefeld-München. First issue, 276 pages, 28 DM, including binder.

This loose leaf work presents a comprehensive representation and explanation on the entire subject of collection, removal, and utilization of refuse from households, communities, industry and trade. Extensive collaboration with local and foreign specialists ensures complete and fundamental explanation, including special problems. It covers all those problems of technical, organizational, and economical kind, which always occur in practice. Extensive information is also given about legal requirements.

The handbook will probably be extended to four parts and later supplemented from time to time following technical developments. The first issue of 276 pages is now available and can be most recommended.

Veterinärhygienische Untersuchungen bei der Verwertung fester und flüssiger Siedlungs-abfälle (Veterinary hygiene investigations of the utilization of solid and liquid community wastes). By Priv.-Doz. Dr. med. vet. Dieter Strauch, Giessen. Bulletin in the field of public health published by Ministerialdirektor Dr. Josef Stralau and Reg. - Med.-Direktor Dr. Bernhard E. Zoller of the Federal (German) Ministry of Health, Bad Godesberg, Number 18, with 27 illustrations and 8 tables. Publisher: Georg Thieme, Stuttgart, 1964, 11 DM.

This work presents for the first time a treatment on veterinary hygiene with questions of urban refuse management. Composting is given primary importance. The main topic is concerned with the question if and under what conditions composts, made by various processes, can be considered unobjectionable from a veterinary hygiene viewpoint. This question is not only reviewed from available literature but is answered through comprehensive experiments by the author. The work contains guides and suggestions for practice and also covers the most important composting processes and gives extensive source and literature bibliography on them. Legal questions are also treated as far as they relate to the topic.

The book presents a valuable and necessary addition to the literature on this subject and should be widely acclaimed by the experts. Of course it remains to be seen if composting will be widely used in urban waste disposal as thought by the author.

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7. VIII International Congress on Public Cleansing, Vienna

The VIII International Congress on Public Cleansing of the International Association of Public Cleansing (INTAPUC) was held April 14-17, 1964, in Vienna. Along with the Congress there was a large international vehicle and equipment show. Organization and conduct of the Congress was done by Obersenatsrat Kojetinsky, Vienna, who also took over as President of INTAPUC for the next four years.

Former INTAPUC President, Ing. Björkman, Stockholm, said at a press conference that the problems of public cleansing are ever-increasing with the growth of cities and the increase in traffic and motorization. The transition from hand labor to motorized and mechanized public cleansing was associated with certain difficulties. For this reason experts were interested in an exchange of ideas as early as the end of the past century. In 1898 British experts formed the British Institute of Public Cleansing. Similar organizations were also formed by other countries. International cooperation grew into more solid form by 1928 and the first International Congress on Public Cleansing took place in 1931 in London.

The "Viennese-Congress 1964" was under the sponsorship of Federal President Dr. Schärf and was attended by more than 1100 experts from 37 countries. At the vehicle and equipment show, 120 European and non-European firms participated. This show presented an excellent review of all makes and designs of various refuse processing plants, collection vehicles for refuse, street sweeping, street washers, self-filling street sweepers, snow plows, a snow melting plant, gravel and salt spreaders, sludge pumping wagons, special vehicles for transport of bulky refuse, and so forth.

The new President of INTAPUC, Obersenatsrat Kojetinsky, declared in his opening speech that special attention must be given today to the protection of surface and underground waters in connection with the dumping of solid wastes from cities and their environs. Because such deposits are unavoidable in many cases, the question of their influence on water must necessarily be solved. Urban waste is treated today in composting and incineration plants so that it is hygienically unobjectionable. Now there is an ever-increasing amount of sewage sludge which must be coped with in sewage treatment plants; the utilization of this or its joint disposal with refuse has not yet been satisfactorily solved economically.

Public cleansing must also concern itself with the problem of air pollution. As the ever-increasing traffic contributes to dust development, it is necessary that streets be cleaned more intensively. Practically dust-free refuse collection is already widely accomplished. One must also wonder if the vehicular equipment for public cleansing cannot be improved. Perhaps an exhaust filter for cleaning discharge gases or an eventual electric drive of some sort might represent a usable solution.

Obersenatsrat Kojetinsky emphasized that public cleansing must endeavor to keep the necessary work as noiseless as possible. The use of noise-dampening material in this field is already widespread but the noise of motors, compressors, exhausts and various special vehicles still represents a bothersome factor in the narrow city streets. Many of the problems could be more easily solved by intensification of international cooperation.

The main points of the lectures and discussions were on four basic topics which will be presented here in very condensed form:

I. Success and Work Performance in Public Cleansing.
Lecturers: A. E. Barton, Director, Birmingham Refuse Utilization Plant and Chairman, Institute of Public Cleansing, and Engineer S. Sundqvist, Director, Stockholm Public Cleansing Department.

A. E. Barton reported on the relationship between management and labor in the public cleansing departments in Great Britain. In retrospect, he told of the bad conditions under which the worker had to labor at the turn of the century. The work was unpleasant, dirty, exposed to all weather conditions and poorly paid. Workers of all other trades rejected this work. Today there are training programs, sufficient health care and a pension plan for the worker. Working time is reduced from 53 hours in the years 1900-1914 to 42 hours per week since 1960. There is also an adequate vacation program. Work hygiene and health care of the worker has been given special attention, particularly regarding work to be done outdoors and in bad weather.

In the public cleansing departments of Manchester and Birmingham, "intraplant talks" have been introduced to give the workers an insight into the problems of plant management and they have often resulted in both sides, worker and management, working very closely together. The worker of the sixties demands the right to have his say in management. He does not want to have anything to do with actual plant management but he knows that he has something to add and the fact that his ideas are given consideration gives him satisfaction. If improvements in the work result, then he will concern himself with such problems in the future.

S. Sundqvist spoke on the success and work performance in the Stockholm Public Cleansing Department, where incentive wages were introduced in 1957. Today over 80 percent of the work is handled through such wages. Experience showed that incentive wages are a tremendous help in obtaining good quality work, high productivity and good economy.

The introduction of incentive wages must give advantages to both management and labor. In Stockholm these wages resulted in a wage increase of 20 percent but at the same time the work force was reduced by 30 percent, the number of machines was reduced and the total output increased. In many cases even the output of the machines rose considerably.

When incentive wages are paid, it is simpler to obtain an adequate work force. Without the possible wage increase which rests upon output increase, it would be almost impossible to obtain replacement workers. With a more just payment for work accomplished; an increase in work incentive, a better working morale and a more pleasant relationship between foreman and worker, are reached.

The speaker also stated that in Stockholm there is appreciable interference from parked cars in the use of street sweepers. A changing No Parking decree was released so that cars are never parked on the same side of the street two nights in a row. This results in alternatively freeing one curb. The center of the city is swept at night and the outer districts are done mostly during the day. An investigation is in process to decide if refuse collection should be done under municipal control. Presently a home owner is required to take his own refuse to a designated dump. In the future, heavy metal containers will probably be replaced with plastic bags in the city districts with buildings higher than two stories. In experiments, a number of advantages have been found: The sacks are light, they weigh only 5 kg but hold 450 or 530 liters. They are also economical because the output of the individual worker increases. Through the exchange system, walking distances are shortened, walls along the carrying path are no longer scratched and, finally, the noise of the metal containers is gone.

Stockholm has a huge problem during winter with snow removal. Streets with 16 million square meters of surface must be cleaned, the total street length exceeds 1300 km, the sidewalks 1800 km. About 650 vehicles for snow plowing and loading and 275 for sanding are used every winter. An average of 1 million cubic meters of snow are transported to the municipal harbor and dumped there.

II. New Research Work of the IRGRD.

Lecturer: Dr. R. Braun, EAWAG, Zürich, Secretary of IRGRD.

The speaker summarized the latest research done by institutions, research laboratories and professional groups associated with IRGRD. He indicated that to date, experiments with refuse materials have been limited to analysis of domestic refuse. This was natural since larger cities and smaller communities were mainly concerned with the residential refuse problem. Today we have an entirely new situation. Household refuse is only a part of the total refuse which must be eliminated. In the future one must be concerned not only with domestic refuse removal but also the building of refuse disposal plants capable of handling bulky wastes, garden refuse, sewage sludge, solid compostable or combustible industrial wastes and oil containing wastes. One is forced to this requirement as space for dumping is becoming very scarce. It must be reserved for disposal of incinerator residues and of the remaining waste materials from incineration and composting.

The speaker then discussed research work on the effects of compost on plants and the soil. Experiments over many years in various countries, especially in the Netherlands, show that the use of compost results in an increase in most of the crops tested. By use of compost it is possible to increase the humus content of the soil and thereby its productivity. In parallel tests in adjoining plots with composts and mineral fertilizers, lasting improvement was noted in plots treated with both mineral fertilizers and compost, compared with plots treated only with fertilizers. Composts are used today in forestry, vineyards, orchards and gardens and have also been used successfully in cultivation of waste land and even in the reclamation of former mining areas.

III. Experiences with the Newest Incinerator Plants.

Lecturers: Dir. R. Dijkshoorn, Director, Rotterdam Public Cleansing, and Senatsrat Dipl. Ing. F. Fischer, Director, Vienna Public Cleansing.

R. Dijkshoorn reported on experience with the Rotterdam incineration plant. He stressed the fact that solid waste removal is becoming an ever-increasing problem in European cities. The simplest method of disposal, dumping, has now been placed under severe restrictions. In the first place there are requirements to prevent the pollution of soil, water, and air; also cities have an increasing tendency to spread out and settle surrounding areas. This tendency is due to better transportation and therefore very greatly restricts the possible new sites for refuse disposal.

It has become practically impossible to find suitable areas for depositing refuse, particularly in Holland which has a very dense population; therefore, various types of refuse processing plants are gaining ever more importance. Thus, hygienic and esthetic qualities place the highest requirements on new incineration plants. A modern incinerator must have freedom from smoke and odor, noise prevention in the vicinity, and architectural fitness for the area. Also the incinerator discharge must be unobjectionable biologically and chemically.

One must plan on a gradual change in refuse quantity and quality in building an incinerator plant. It has been noted in Western Europe that the quantity increases with the growing prosperity. It has also been shown that the calorific value of refuse increases. For example, the calorific value of summer refuse in Rotterdam has increased 60 percent in the last 10 years. The refuse quantity has increased 15 percent in the last 3 years, even though the population of Rotterdam has hardly changed.

Senatsrat F. Fischer spoke on the Vienna incinerator plant. The intent to build an incinerator in Vienna goes back to 1927. That same year, the reorganization of the refuse removal system, begun in 1923, was nearly completed. The Colonia system replaced refuse collection with open wagons and various type containers. Vienna was thus the first city of a million to have hygienically trouble-free refuse collection with uniform refuse vehicles, organized according to modern principles. It was then also time to solve the problem of refuse disposal. Several projects were planned for refuse incinerator plants, but, the arrival of the economic crisis prevented their construction. The plans could not be realized during the war and the early post-war years also. But almost 10 years ago the city administration undertook energetic steps concerning refuse disposal.

First the idea of refuse composting was pursued and that resulted in construction of the first Vienna composting plant, the "biomull" plant, in 1956. The plant has been operating continually since then. The compost, "Biomull," finds a very good market in the city garden department, vegetable growers, wine growers, etc.; for them refuse compost is a welcome aid in the improvement of their soil. Operation of the compost plant is conducted without financial aid. Income covers not only the operating costs but also the interest and repayment of the plant. Of course, the plant can only process 60,000 m^3 of raw refuse per year of which about 1/4 to 1/3 remains as waste for dumping. Even an enlarged plant, planned for a reasonable time, cannot solve the problem of refuse disposal because in the meantime the refuse output steadily increases.

The refuse output was already 550,000 m^3 in 1954, an amount which can only be handled by incineration. The first question was whether to build one large plant or several smaller plants. The city of Vienna decided to build several incinerators since this solution presented less traffic problems for collection vehicles than transportation to a central plant. The higher costs for construction and operation of several plants can be balanced by better utilization of heat generated. Three plants are planned for Vienna to be located at the edge of the city.

Very good utilization of excess heat was envisioned for the plant planned for the west of the city by the heating of two large hospital complexes situated near the Flötzersteig. In addition, a municipal central laundry will be added later in the same vicinity. After thorough preliminary trials, the contract for the first incinerator plant near Flötzersteig was let in the fall of 1959 (von Roll system). Construction began in the spring of 1960 and a year ago, on April 25, 1963, the first refuse was burned in the plant.

A number of results and experiences can be reported as of the end of 1963 from operation of the plant. The speaker noted that the plant burned about 50,000 tons of refuse and produced about 80,000 tons of steam. Comparisons have shown that the refuse has changed in calorific value in the past few years. The paper content has considerably increased with substantially higher calorific value of the refuse. For example, the heat value in Bern increased almost 40 percent from 1955 to 1962. The high paper content of refuse also results in reduced density. The refuse in Vienna had a density of 314 kg/m^3 in 1954, but by 1963 it had dropped to about 200 kg/m^3. These and other findings will be used in planning the second incinerator. With two incinerator plants, the problem of refuse disposal will be solved for a long time. Proceeds from the sale of steam not only cover the operating costs but also, as has already been determined, the amortization costs.

IV. Modern Vehicles and Equipment for German Public Cleansing Plants.
Lecturers: Dir. i. R. W. Kaupert, Bad Schwartau, Manager, Technical Committee of VKF, and Baudir. Dipl. Ing. O. Tope, Hannover.

W. Kaupert pointed out that the introduction of refuse cans and barrels with hinged lids is a decisive measure in the interest of hygiene even though dust formation during refuse collection has been reduced by the transition to oil heating and the associated reduction in ash content of refuse. The cover protects the contents from rain and wind and hinders the access of insects and rodents. The modern refuse truck permits practically dust-free emptying of the containers. With pneumatic lifts and hydraulic compaction, much heavy work of the collectors is eliminated today. It is only for this reason that adequate personnel can be found in Germany in view of the acute labor shortage.

To prevent health damage to the worker, it was necessary to prevent exposure to exhaust gases which was accomplished by locating the exhaust up behind the cab. This was also advantageous for noise prevention.

After the war, new suburbs were often built with dead end streets to prevent heavy traffic and permit quiet living. It has now been found that the heavy public cleansing trucks have difficulty turning in these streets. For this reason it will be necessary to ask municipal building departments to prevent construction of such dead end streets.

O. Tope stated in his talk that motorized traffic acts in a certain sense in a cleansing manner as the traffic wind often sweeps the dirt into the gutter where it only has to be picked up. Parked traffic, however, is the worst hindrance to the street sweepers. German laws must be changed to prescribe alternate parking. Without this regulation it will be impossible to use street cleaning and winter service vehicles efficiently. Also. cleaning by hand labor is not satisfactory.

The lecturer then spoke of various systems of street cleaning machines such as self-loading street sweepers, sprinklers, spreaders, etc. The most complete type of street cleaning consists of washing the street surface. This cleaning method gains in importance since a dangerous surface deposit originates through rubber particles, exhaust dirt, lost oil, etc. This deposit is very dangerous for the traffic during rains. Such danger is especially great in industrial areas as shown by the increase in accidents during long rains or at the beginning of a rain. Spraying the street with water under pressure and the use of rubber squeegees alone does not bring the desired effect. This is only attained through the use of rotating, multi-finned wash rollers.

The speaker noted that snow removal will be more and more mechanized as the years pass in order to save time and because of the lack of laborers. This is done by the use of snow loaders, blowers, and shovel loaders which permit the snow to be loaded directly on the trucks. Snow loaders have the disadvantage that they do not operate efficiently in frozen and iced snow. The snow-melting process, tried in previous years, again gains importance after renewed experiments in the USA and Russia. This is because dumping of snow is limited in large cities and the snow must be removed from major streets. This apparatus will also appear in Germany sooner or later.

Interesting details on the installations in Prague were given by A. Burger, Director of Public Cleansing. Prof. Minoru Shirakawa, Waseda University, explained the refuse problem in Japan.

The lectures, conferences, and discussions, on which we cannot dwell in detail, were excellently supplemented by practical demonstrations of various machines for street cleaning, and trips to the incinerator at Flötzersteig and the biomull (composting) plant.

The well-organized Congress presented valuable cultural and social events as well as technical information. The highlight of these was the reception by the Mayor of Vienna, Franz Jonas, in the large reception room of the City Hall. It was also arranged that the Congress dance! The connection between the Viennese waltz and municipal cleansing was shown in that a member of the Strauss waltz dynasty, Josef Strauss, not only composed immortal melodies but also designed a street cleaning machine.

Possible sources for the Information Bulletin in German, French, Italian, and English languages:

Switzerland (German and French):	Sekretariat der IAM, Dr. R. Braun, Physikstrasse 5, Zürich 7/44.
Germany (German):	Generalsekretariat der AkA, Oberbaurat Dr. H. Straub, Stadtbauamt, Baden-Baden.
The Netherlands (German & French):	Stichting "Compost," Dir. Dr.-Ing. Stolp Jac. Obrechstraat 67, Amsterdam-z.
France, Luxemburg (French):	Union des villes et communes belges, Dir. B. de Grunne, 30 rue aux Laines, Bruxelles.
Israel (German and French):	Inter-Ministerial Committee for Utilization of Urban Refuse, Dir. L. Watson, Ministry of Health, Jerusalem.
Italy (Italian):	Instituto di Ingegneria Sanitaria, Prof. Dr. Ing. E. de Fraja Frangipane, P. Leonardo da Vinci 32, Milan.
U.S.A., England and other English-speaking countries (English):	Superintendent of Documents U.S. Government Printing Office Washington, D.C. 20402
Other European and extra-European Countries (German and French):	Sekretariat der IAM, Dr. R. Braun, Physikstrasse 5, Zürich 7/44.

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